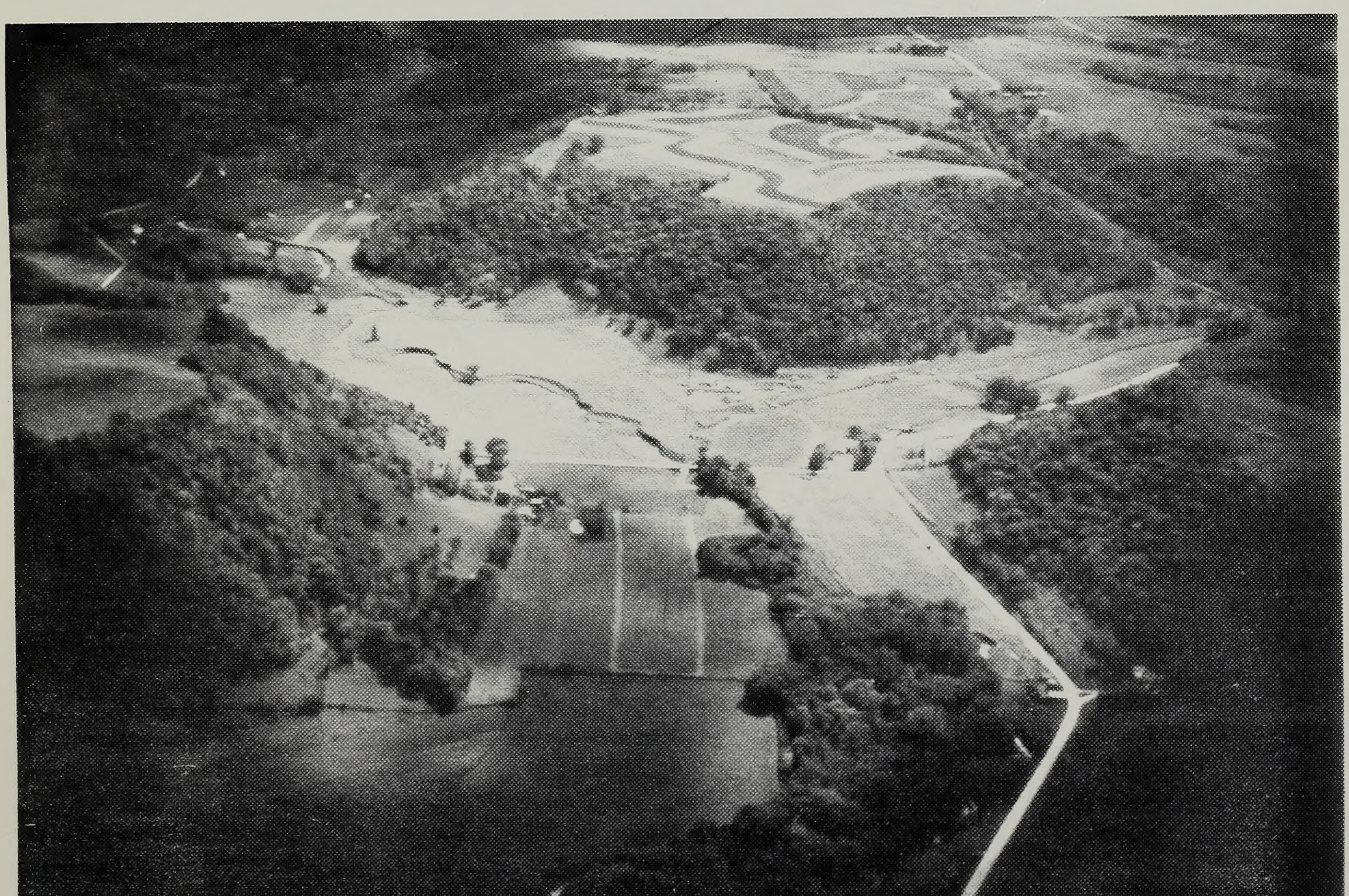
Special 10 Year Report

Rural Clean Water Program

Garvin Brook Project



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EXECUTIVE SUMMARY

The government agencies and landowners in Winona County became involved with the Rural Clean Water Program when they were notified by state level USDA agencies that the program existed. Three seperate watersheds in the county were suggested as possible project sites. Joint meetings were held with local agencies from other counties which share areas of two of the watersheds. In the end, it was decided that the best opportunity for success would be to choose the watershed that was completely contained in Winona County - the Garvin Brook Watershed.

Agency personnel then met with members of the Garvin Brook Citizens Committee and other interested landowners to introduce the program and determine if there would be adequate backing for the project. Local support appeared to be very enthusiastic so application for funding was made by the agencies involved.

When the Local Coordinating Committee received word that funding was approved for the Garvin Brook RCWP, the project was announced immediately through all forms of media and landowners were encouraged to come to the Ag. Service Center to obtain details about the program and enter into contracts to complete Best Management Practices. After signing the first few contracts it became clear that the landowners did not realize initially that they would be required to correct all water quality problems on the area of the farm located in the project area. Many assumed that they would sign up for the practices that they wanted, when they wanted, and that would be the extent of their participation. Also, the first animal waste system designed under the project was a comparatively expensive system. And many producers in the project area had been pasturing the stream bank. When they were told that they would need a waste system and/or that they would be required to fence the cattle out of the stream, they refused to sign.

It became difficult to work with potential participants after the initial newness of the project wore off, mainly because they felt the practices were too expensive, or that they could not adapt certain BMPs to their operation. Also, the years 1983 - 1987 saw a period of moderate to severe financial hardship for most farmers. As participation began to lag, some bickering began between agencies and within agencies regarding responsibilities and questions were raised whether the public was still behind the project.

As the project progressed and monitoring data was obtained, it became evident that with the karst topography of the area, it was impossible to differentiate between surface water and groundwater. The LCC decided to expand the project area to include the groundwater recharge area of Garvin Brook. BMPs

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As the project progressed and monitoring data was obtained, it became evident that with the karst topography of the area, it was impossible to differentiate between surface water and groundwater. The LCC decided to expand the project area to include the groundwater recharge area of Garvin Brook. Since

that would limit the leaching of nitrate-nitrogen into ground water were emphasized. Sinkhole repair and abandoned well sealing practices became an important part of many of the contracts signed by producers in the expanded area. Conservation tillage practices gained additional acceptance and the Local Technical Committee developed an addition to BMP-15 - Fertilizer Management entitled Split Nitrogen Application.

The well water sampling of the Garvin Brook area began in 1983 and the results of this testing encouraged increased participation and the use of these BMPs in the groundwater recharge area. It is a fact that there are many variables which determine the amount of nitrate-nitrogen in an individual well but producers became more conscious of what they could do to attempt to alleviate the high levels of this chemical in the well water aquifers.

As time to sign contracts expired, the LCC was somewhat disappointed about how many landowners had participated. One family in particular allowed their beef herd to over-graze much of the riparion area and woodland above the south branch of Garvin Brook and also pastured the stream itself. One of the family members even attended LCC meetings initially but they could not be convinced that these practices are detrimental to quality of the brook water.

It will be interesting to study monitoring results from well samples or the water tests done in 5, 10 or 20 years from now to determine whether these practices have made a difference in the quality of the surface and ground water of the Garvin Brook area. Agencies and groups involved felt proud to be a part of this project and are convinced that the efforts made by everyone will have a positive effect on water quality, not only in the Garvin Brook watershed but throughout the area and beyond.

.0 PROJECT FINDINGS AND RECOMMENDATIONS

- Don't be afraid to expand project if newly realized problems are identified that can be addressed through program.

- Ensure adequate funding/assistance is available to perform monitoring activities before, during and after project. Monitoring provides justification, shows results and identifies potential project weaknesses. It is as important as any other phase of the project.

- If certain BMPs are not accepted by potential participant, adjustments should be made to develop contracts that provide as much treatment as possible. The sponsors best judgement must be used in deciding what BMPs can be forgone in which cases for the good of the project. Example: stream corridor fencing.

- RCWP should include funds to hire a project coordinator who would not have close ties but be familiar with all government agencies involved. This individual would also be comfortable with communicating one on one with project area landowners and participants.

- Pre-screen potential participants to establish project participation. Make sure they know and understand the requirements if they sign a contract.

- Have plot studies and field demonstrations in the project area to convince and encourage producers to participate and give them confidence in the BMPs.

- A period of time should be allocated for gathering baseline data before implementation of BMPs. Water quality monitoring and data evaluation are essential in showing the need for BMPs.

2.2.1 Overview of Project

The Garvin Brook watershed is centrally located in Winona County, Minnesota which is in southeast Minnesota. Winona County's eastern border is the Upper Mississippi River.

Dairying and cash grain operations are the primary farm enterprises.

Water quality problems exist in both the surface water and in the groundwater resources.

The original project area was the surface watershed area of Garvin Brook. An additional area, the groundwater watershed of Garvin Brook, was added to the project in 1984. Also added to the project was BMP-15 which provides participating producers an incentive payment to apply a percentage of their nitrogen needs before planting and the remainder after the corn plant has reached a stage of maturity that can better utilize the additional fertilizer.

At the commencement of the project, the critical area was defined as those areas within 300 feet of open flowing water, sinkholes, abandoned or contaminated wells, and feedlots that had a high rating in the Minnesota Pollution Control Agency Animal Waste modeling system. In 1985 the critical area of the project was redefined. The addition of the groundwater watershed required that the critical area be increased. Also, the AGNPS I Model has allowed the technical agencies to become quite specific in designating priority areas for needed treatment.

Since 1985, the designated critical area has included that portion of the groundwater watershed area that has a high susceptibility for groundwater contamination, and those subwatershed areas in the surface watershed area with high and moderate sediment loads and moderate nitrogen and phosphorous loads.

In August of 1987 the LCC submitted an amendment to the existing plan of work to the RCWP NCC to allow for additional contracting through 1989. In March of 1988 the LCC received word that their request was granted and $292,000 additional funding could be encumbered for BMP's. A copy of this amendment as well as tables reflecting additional cost is attached to this report.

2.2.2 Climate, Physical Setting, Population

Climate Description

Winona County is cold in winter and quite hot with occasional cool spells in summer. Precipitation during the winter frequently occurs as snowstorms, and during the warm months it is chiefly shower, often heavy, when warm, moist air moves in from the south.

The total annual precipitation averages 33 inches. 24 inches or 75 percent of the total usually falls in April through September, which includes the growing season for most crops.

The average annual snow fall is 48 inches. On the average, 52 days have at least 1 inch of snow on the ground.

In winter, the average daily temperature is 17 degrees F. The average daily minimum temperature is 7 degrees F. In summer, the average daily maximum temperature is 82 degrees F.

On the average, Winona County has 2,708 growing degree days annually.

Physical Setting

Surface Watershed area

The Watershed is characterized by narrow ridges (less than 1/2 mile wide) and deep, broad valleys (less than 3/4 mile wide). The relief ranges from 400 to 600 feet. Slope lengths average approximately 400 feet.

Soils on the ridges consist of silt loams ranging from 1-15 feet thick on summits, and cobbly loams on the sideslopes. The ridges are underlain by sandstone and dolomite bedrock. Narrow terraces and flood plains, primarily consisting of silt loam soils characterize the valleys.

The water shed is approximately 45% farmed summits and upper sideslopes, 35% unfarmed valley sideslopes, and 20% valley.

Groundwater Area

The watershed is characterized by broad ridges (1 to 2 miles wide narrow drainageways throughout, and narrow valleys (25 to 75 feet wide). The relief is less than 200 feet. Slope lengths average approximately 200 feet.

Table 2.2.2

Size & Number of Farms
In the Entire Watershed Area

Size (Acres)	Number	% of Total Acres	% of Total Operations
0- 99	41	2%	13%
100-199	82	12%	26%
200-499	122	45%	45%
500-999	39	31%	15%
1000+	4	10%	1%
Total	288	100%	100%

Soils on the ridges consist of silt loams ranging from 3 to 20 feet thick on the summits, and cobbly loams on sideslopes. The ridges are underlain by sandstone and dolomite bedrock. The valley soils are silt loams and loams with cobbly sediments at the base of gullies that dissect the valley sideslopes.

The watershed is approximately 85% farmed summits and upper sideslopes, 15% unfarmed sideslopes, and 10% valleys.

Population

There are approximately 46,516 acres in the entire watershed. About 67% (31,282 acres) of the watershed is cropland, 17% (8075 acres) is woodland, and 9% (4081 acres) is pastureland. Approximately 2% (930 acres) is in urban land use. The remainder consist of roads, highways, railroads and other uses.

The breakdown in size of the farming operations is shown in Table 2.2.2.

2.2.3 Land Use and Existing Agricultural Practices

Basically, most of the Best Management Practices utilized under the RCWP were available and applied by watershed land-users prior to the project inception.

Some were applied on a very limited basis due to high cost and low short term returns. An example would be BMP-2 Ag Waste Management System. At an average cost of $60,000, the average watershed land-user could not justify the expense involved. RCWP have these land users an opportunity to develop this BMP and reduce pollution potential.

BMP-11 sinkhole treatment and BMP-11 abandoned well treatment were practices developed to address specific water quality concerns that required new technology. These practices were not being utilized prior to RCWP.

BMP-10 (streambed protection) was used very little and not accepted by watershed land users. It was also a practice that had to be removed before wide spread participation in the program took place.

Good land treatment was prevalent prior to project inception with practices such as conservation tillage, crop rotations, contouring and contour strip cropping being the norm.

2.2.4 Water Quality Problems and Impaired Water Uses

Surface Water-Garvin Brook-Upper Garvin

Upper Garvin Brook is a high quality trout stream about 5.0 miles in length. This stream is not stocked. Trout standing crops are depressed in pastured areas. Siltation from the upper watershed is hot as big a problem as a Stockton Valley Creek, however, fine subtrates do decrease the productivity to some riffles and pools. Maximum temperatures in the lower most reach approach being marginal for trout during periods of temperature extremes.

Surface-Garvin Brook-Lower Garvin

Lower Garvin Brook is 10.2 miles long from the mouth to the dam at Stockton. Trout quality diminished rapidly in this section of the stream. Stocked fish contribute a small portion of the trout population in this reach. Between mile marker 9.0 and 8.0 standing crops of trout drop below ten pounds per acre (1982 assessment data). Water temperatures become marginal in lower five miles of stream.

Trout reproduction is limited because of turbidity, lack of coarse bottom substrates, and unfavorable water temperatures. Lower Garvin Brook has natural physical characteristics which classify it as a marginal trout stream (low gradient, wide flood plain, fine substrates and marginal temperatures). These characteristics are severely aggravated by water quality problems in the watershed.

Trout are limited in Lower Garvin largely because of siltation (especially Stockton Valley). Siltation occurs as both a chronic problem and an acute problem during floods. Bank sloughing after floods in a especially severe problem on Lower Garvin.

Surface Water-Stockton Valley Creek

Stockton Valley Creek is about 7.0 miles long. Because of intense pasturing of the stream corridor and contributions of the stream corridor and contributions of fine sediments from the upper watershed, trout productivity is extremely limited in this stream. Stockton Valley Creek also contributes to much of the siltation problem in Lower Garvin Brook, making that stream more marginal for trout. Stockton Valley Creek is not stocked, although some trout present are escapees from commercial fish rearing operations. Standing crops of trout average about 25 lbs/acre (1981 survey) in

pastured lowered reaches of this stream. A low percentage of the stream flows through a wild wooded corridor.

Trout Productivity

Sediments and the associated temperature increases are the major limiting factor for trout in the watershed. Sedimentation fills in trout cover, covers up food producing and spawning substrates, negatively effect incubation trout eggs and fry, and causes an increase in water temperatures.

Older and Abandoned Wells

Many older and abandoned wells were ungrouted and used thin-walled casing, which rusts out and permits surface water to enter the well. Also, it was common practice to case older wells only to the first bedrock formation and to leave the rest of the well as an open borehole. This type of construction interconnects aquifers and allows the rapid vertical movement of contaminants to lower aquifers.

Improperly abandoned wells, particularly multiple-aquifer wells, pose a potentially serious threat to groundwater quality by providing pathways for surface water contaminants to enter a bedrock aquifer.

The Minnesota Department of Natural Resources has a policy to seal all known abandoned wells on property they own and on all new land they acquire.

Sinkholes

Sinkholes range in size from less than 3 feet to as much as 100 feet is diameter and from 1 foot to 30 feet in depth. The rate of sediment transport through the sinkhole, the interaction between surface water and groundwater, and the rate of bedrock dissolution determine whether the sinkhole is either actively subsiding or passive. Each of these factors may change with time and it currently is not possible to predict the exact locations of future sinkhole development.

The funneling of surface contaminants into groundwater is increased by erosion around the sinkhole as it develops and forms a surface drainage basin. Agricultural chemical runoff from fields, barnyard runoff, field or septic tiles entering the sinkhole, and waste products such as hazardous chemicals and dead animals thrown into a sinkhole will contaminate the groundwater.

Other environmental problems created by sinkholes are physical. All types of facilities such as sewer lines, roads, and building foundations may be structurally damaged when a sinkhole opens. Water retention facilities such as liquid manure storage lagoons, municipal waste treatment ponds, and farm ponds are highly susceptible to sinkhole collapse, in as much as these structures change the water saturation and lower the shear strength of surficial materials. Sinkholes that develop under facilities storing potential groundwater contaminants will drain the pollutants into the groundwater.

Many sinkholes form catastrophically when the soil collapses under its own weight. However, not all sinkholes form this way. Surface depressions, referred to as subsidence sinkholes, occur slowly as sediment subsides into enlarged joints.

Figure 2.2.4 shows the location of mapped sinkholes within the watershed. (Winona County Atlas Series, Atlas C-2, plat 5 of 8, Minnesota Geological survey). This map only has the location of known sinkholes at the time of publication and is not necessarily a representation of every sinkhole in the watershed. Sinkholes have been discovered which do not appear on the map.

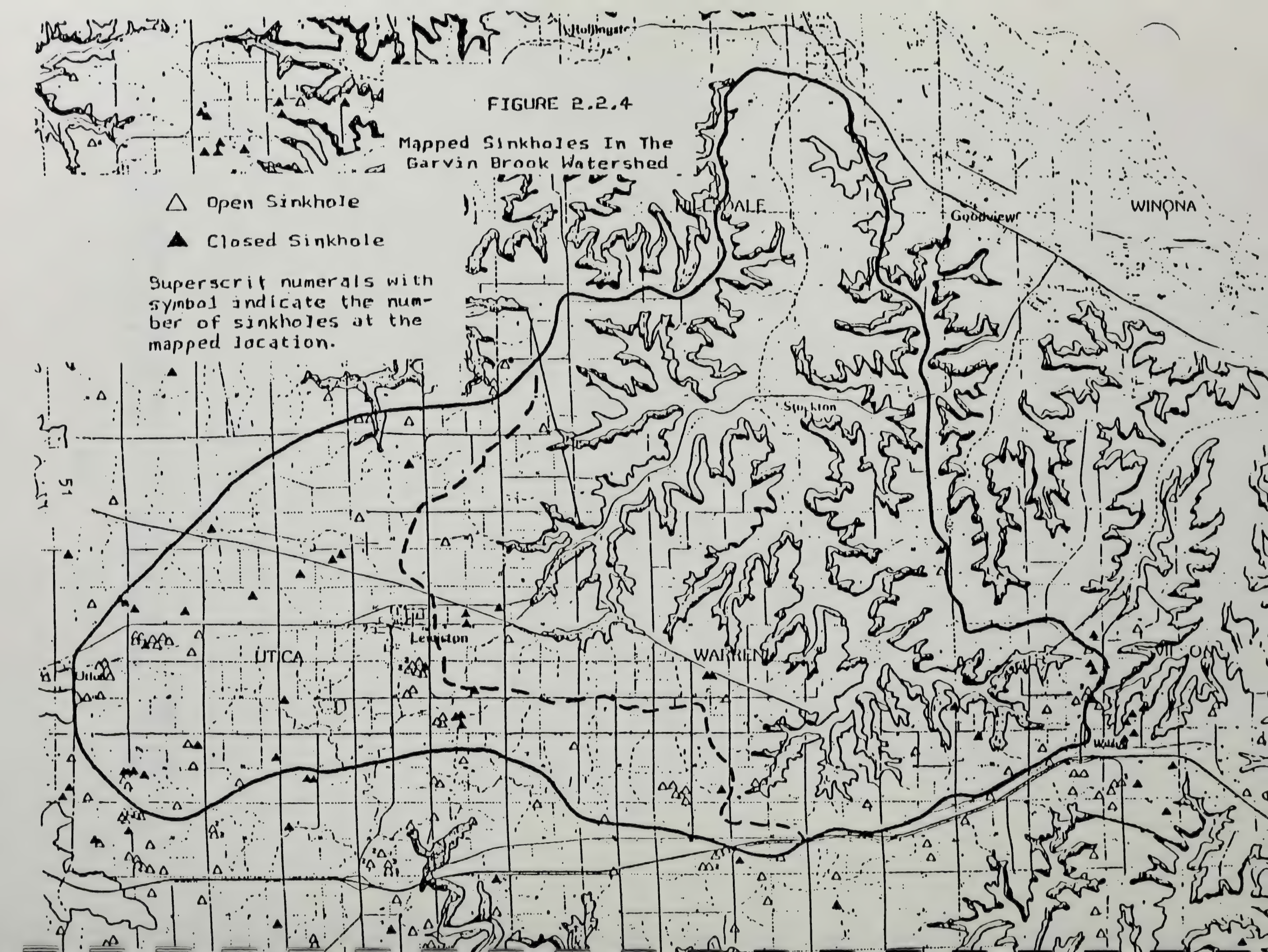
According to the map (Figure 2.2.4) there are 99 known sinkholes within the entire surface and subsurface watershed. 78 of these sinkholes were open or untreated at the time of publication. 60 are in the subsurface watershed and 18 in the surface watershed. At present, there are still 62 open sinkholes, 46 in the subsurface watershed and 16 in the surface watershed. The figure has been updated for this report to accurately portray the locations of sealed and unsealed sinkholes in the entire watershed.

2.2.5 Project Justification

The LCC had three different watersheds to choose from when they determined that they would apply for an RCWP. The Garvin brook area is totally in Winona County, comparatively small and distinct. To this end the landowner population and the agencies and groups involved would find participation more personal. Monitoring and evaluation activities were also able to benefit from the compactness of the area. Some baseline data had already been gathered on Garvin Brook water through proposed flood control projects. This allowed the monitoring agencies to begin testing for changes soon after the first BMP's were completed. A Garvin Brook citizens group was active. For these reasons the LCC chose the

FIGURE 2.2.4

Mapped Sinkholes In The Garvin Brook Watershed



Garvin Brook Watershed. The Garvin Brook Watershed also had distinct water quality concerns that could be addressed.

2.3 Project Goals and Objectives

2.3.1 Findings and Recommendations

RCWP projects were intended to be experimental, to allow technical agencies to try innovative ideas to treat water quality problems. If the goals and objectives at the end of the project were different than those developed at the start of the project, it doesn't mean the project was a failure or poorly developed.

When the Garvin Brook RCWP began, we targeted and identified surface water problems as our critical area. In 1985, the AGNEPS computer model and a newly published county Geologic Atlas helped us identify a growing groundwater problem. We expanded our critical area to include the groundwater recharge area in an effort to positively affect this resource. After 10 years we feel we have successfully addressed both of these problems.

If a critical area is adjusted or expanded, additional BMPs will need to be developed. Evaluations and monitoring programs will also require adjustment or expansion.

2.3.2 Implementation and Water Quality Goals and Objectives

A. Final

Surface Water

Goal - To increase the recreation potential of Garvin Brook.

(1) Water quality improvements will focus on the trout fisheries.

(2) Water quality improvements will focus on enhancing contact activities and aesthetics.

Objectives -

(1) To decrease the sediment loading by 50%. This would be a reduction of 5,981 tons of sediment for a 25-year, 24-hour rainfall event.

(2) To decrease turbidity violations from 100% to below 15%.

(3) To decrease fecal coliform bacteria violations from 79% to below 40%.

Groundwater

Goal - To decrease biological and chemical health related pollutants entering the groundwater aquifers.

(1) Water quality improvements will focus on lowering health related nitrate-nitrogen values in the karst area.

(2) Water quality improvements will focus on reducing other health related pollutants.

Objectives -

(1) To reduce the NO-N (nitrate-nitrogen) load to the acceptable drinking water standard, which is below 10 mg/L (ppm) nitrate-nitrogen.

B. Initial

Surface Water

Goal - To increase the recreation potential of Garvin Brook.

(1) Water quality improvements will focus on the trout fisheries.

(2) Water quality improvements will focus on enhancing contact activities and aesthetics.

Objectives -

(1) To decrease the sediment loading by 50%. This would be a reduction of 5,981 tons of sediment for a 25-year, 24-hour rainfall event.

(2) To decrease turbidity violations from 100% to below 15%.

(3) To decrease fecal coliform bacteria violations from 79% to below 40%.

C. Adjustments and Refinements

The original project area was the surface watershed area of Garvin Brook. An additional area, the groundwater watershed of Garvin Brook, was added to the project in 1985. Also added to the project was BMP-15 which provides participating producers an incentive payment to apply a percentage of their nitrogen needs before planting and the remainder after the corn plant has reached a stage of maturity that can better utilize the additional fertilizer.

At the commencement of the project, the critical area was defined as those areas within 300 feet of open flowing water, sinkholes, abandoned or contaminated wells, and feedlots that had a high rating in the Minnesota Pollution Control Agency Animal Waste modeling system. In 1985 the critical area of the project was redefined. The addition of the groundwater watershed required that the critical area be increased. Also, the AGNPS I Model has allowed the technical agencies to become quite specific in designating priority areas for needed treatment.

Since 1985, the designated critical area has included that portion of the groundwater watershed area that has a high susceptibility for groundwater contamination, and those subwatershed areas in the surface watershed area with high and moderate sediment loads and moderate nitrogen and phosphorous loads.

2.3.3 Inventory and Evaluation Goals and Objectives

The goals and objectives of the inventory and evaluation section of the Garvin Brook RCWP were to increase local awareness of local surface and water quality problems and issues. Landowners were expected to utilize that awareness and make adjustments in their management styles that would positively affect the watershed surface and groundwater resources. One avenue was to develop a contract through our RCWP program.

Tools utilized to increase local awareness of surface and groundwater problems included:

1. Public information meetings

2. Water quality tours

3. Quarterly news letters

4. Demonstrations

5. Well water analysis

6. Tillage, nitrogen and pesticide plots

7. Media coverage

8. Individual contacts and contract development

9. Soil analysis

10. Agricultural waste analysis

11. Farmer surveys

12. Surface and groundwater studies and monitoring

2.3.4 Economic Evaluation Goals and Objectives

The economic goals and objectives of the program included financial assistance to landowners in the project area at such a level to provide incentive to complete needed BMPs. BMPs such as animal waste utilization, conservation tillage, and fertilizer/pesticide management were designed to show the producer how to decrease input expenses with continued use. Cost-shares were set at 75% of the average cost as determined by the LCC. Cost-shares to an individual participant are limited to $50,000.

As the project moved through the mid '80s and agriculture experienced economic hardships, the project became very important as an avenue for much needed capital throughout the entire local agricultural business community.

2.3.5 Water Quality Monitoring Goals and Objectives

A Final Monitoring Objectives

Stream Water Quality Monitoring

The final (post 1986) goals of stream monitoring were to monitor baseflow water quality, stream runoff following storm events and brown trout populations in order to evaluate stream water quality changes occuring throughout the RCWP BMP implementation period. More specifically, the monitoring objectives were to:

1) Conduct continuous monthly sampling for 17 parameters at a site near the mouth of Lower Garvin Brook, in order to evaluate trends in baseflow water quality;

2) Conduct brown trout surveys in the spring and fall each year at control sites on Upper Garvin Brook

3) Conduct storm event monitoring to verify and AGNPS model and use this mode to estimate storm event sediment and nutrient loading reductions due to RCWP BMPs.

Ground Water Monitoring

The final (post-1986) goals of ground water and vadose zone monitoring were to:

1) Develop adequate "baseline" data regarding nitrate and pesticide concentrations and general chemistry of the Prairie du Chien-Jordan aquifer in Garvin Brook Watershed and Ground Water Recharge Area so that long term changes resulting from the RCWP and other programs could be assessed

2) Determine nitrate and pesticide concentrations moving through the rooting zone in fields that had been under RCWP contract for two to four years

3) Evaluate nitrate and pesticide contributions from agricultural fields, sinkholes, grassland, woodland and ponds in an effort to better characterize the contamination

4) Evaluate well water nitrate concentration changes between 1983 and 1990 from annual sampling of numerous domestic wells

5) Develop a greater understanding of ground water residence times in order to more appropriately evaluate ground water quality trends.

B Initial Monitoring Objectives

Stream Water Monitoring

The initial intent of stream monitoring was to conduct intensive baseflow and runoff event monitoring for three consecutive years at three sites in order to adequately define baseline water quality. More specifically, the monitoring objectives were:

1) Evaluate which water quality parameters were of greatest concern;

2) Define the initial baseflow quality of streams at three sites in the watershed so as to allow for future documentation of changes resulting from implementations of BMPs;

3) Characterize pollutant loadings during rainfall-runoff events;

4) Continue trout population assessments each spring and fall so that time trends can be established.

Ground Water Quality

1) Establish baseline ground water quality within Garvin Brook Watershed so that man-controlled changes in quality could be detected with time by sampling 15 wells and 3 springs in Garvin Brook Watershed.

2) Heighten the awareness of ground water quality problems in the Garvin Brook RCWP area by sampling numerous wells for nitrate.

C Adjustments and Refinements

Many adjustments were made in the monitoring program throughout the project duration. There was a change in project emphasis to include ground water when it was discovered that: 1) 20 to 25 percent of wells in Garvin Brook Watershed had nitrate-N in excess of 10 mg/1, 2) the groundwater recharge area for Garvin Brook Watershed extended about five miles west of the surface watershed boundary, and 3) there was a reluctance for land owners to adopt certain stream protection BMPs. As a result, the area of ground water sampling and number of wells sampled increased in 1985.

It was also realized that many of the original 15 wells and 3 springs yielded water that reflected land use activities decades or centuries ago. It was decided that sampling of the Vadose zone and upper most aquifer would be necessary to determine the impact of the RCWP on ground water quality.

Once pesticides were found in ground water, there was an increased emphasis in pesticide monitoring. Eventually, it was determined that wells with the highest pesticide levels were indicative of point source related activities. This discovery also resulted in an adjustment in the pesticide monitoring strategy.

Decreased emphasis in stream monitoring occurred due to budgetary contraints, change in project emphasis, difficulties in obtaining storm event data, and problems in maintaining three sites. A renewed storm event monitoring effort was prompted by an increase in storm event computer modeling efforts.

2.4 Project Development

2.4.1 Highlights of Project Development

There was excellent cooperation between a number of agencies during the project. As a result of the U.S. Geologic survey, the Garvin Brook Project area was expanded to include additional acres where groundwater flow could be included. This allowed for the opportunity to conduct nitrogen demonstration plots, and root worm insecticide rate plots in the program. In cooperation with the Minnesota Dept. of Agriculture, the Extension Office began in 1983 a well sampling program on 80 wells. This was developed to look at nitrate/nitrogen levels in wells in the project area. The Minnesota Dept.

of Agriculture analyzed the samples at no cost. In 1985, the sampling was expanded to 146 wells. In 1986, the sampling was expanded to 161 wells and has stayed at that level through 1991. Therefore, nine years of sampling has taken place. The results have been mapped with a color code for display.

In 1988, the Extension Office started a 12 well 5 week interval well water study for nitrate/nitrogen. These wells were chosen strategically located in the Garvin Brook Project area to look at structure of the well, distance from sinkholes, age and depth of the well. The wells were picked in consultation with a hydrologist and a geologist at Winona State University in Winona.

Since 1985, the University of Minnesota Soil Scientists have cooperated in conducting nitrogen rate management plots in the county.

2.4.2 Summary of Annual Achievements

The well water study and mapping has generated great public awareness and understanding of the issue of nitrate/nitrogen residue in the goundwater. The map and water test results has been used dozens of times in giving presentations to different organizations, groups and the public in general over the years. Results show that in 1986, 37% of the wells contained more than 9.9 ppm of nitrate/nitrogen while 1990 it has been reduced to 26.7% of the wells showing 9.9 ppm of nitrate nitrogen. The nitrogen rate management plots have raised the awareness to the public and to the farmers, specifically, on proper application rates. Field tours at the plot sites have been conducted each year since the plots were started in 1985. Also, results of those studies have been discussed and distributed at winter farmer educational programs.

The corn rootworm insecticide rate studies have also been used to raise awareness of when to scout for beetles to determine if insecticide is needed and timely application procedures. In results of a 1990 study, rootworm infestation was the same at recommended label application rates at 75% and at 50% recommended rate. A cost share split nitrogen application rate program has been successful in reducing the amount of nitrogen applied by cooperating farmers. Using University of Minnesota Extension recommendations, farmers have been able to reduce the amount of nitrogen applied by determining yield goal, legume credits for plowdown, and manure application credits. This program has been conducted since 1985. In 1989, with 60 farmer cooperators covering 6,454 acres, there was an average savings of 44 lbs per acre.

2.5 Changes in Land Use Patterns and Water Resource Management Throughout Project Period

2.5.1 Impacts and Effects of Federal Programs

Because Winona County and particularly the Garvin Brook watershed area is predominantly livestock producers, the impact of the PIK program was somewhat tempered. The impact was greatest in those years when producers could take advantage of the posted county certificate price being significantly below the loan rate. This encouraged the production of more acres of corn.

The Dairy Refund Program (DRP) and the Dairy Termination Program (DTP) had a more pronounced impact and effect on the project area. Roughly one third of the RCWP participants were involved in the DRP and 3 were accepted into the DTP. Many DTP participants who no longer have any livestock found it difficult to keep enough hay in their rotation to satisfy their conservation plan.

The Conservation Reserve Program (CRP) had a minimal impact on land use and water resource management in Garvin Brook. Farms and acreage in CRP are small and scattered throughout the project area and probably had the least effect of all Federal programs. Garvin Brook acres in CRP would decrease the soil and nutrient loss due to runoff and would also decrease the use of fertilizer and pesticides.

2.5.2 Impacts and Effects on Cropping and Chemical use Changes

In a 1989 Extension Herbicide plot, weed control methods were studied looking at rotary hoe and cultivation, herbicide and cultivation, two cultivation only, and herbicide only. Results showed no significant difference in yield between the various weed control methods. A farmer field tour was held at the plot site. Results were also discussed at winter meetings.

Crop producers are reducing chemical usage in the county and more cultivation is taking place than five years ago. Even farm chemical dealers have been coming to educational meetings and plot tours and are more conscientious of herbicide recommendations to their customers.

Nitrogen application rates have decreased over the past few years in the Garvin Brook RCWP area. The University of Minnesota Soil Service Dept has cooperated with the local Extension Office in conducting nitrogen application rate plots. Using results of those plots at the plot sites and at winter farmer meetings, farmers are making a

conscientious effort to reduce their nitrogen rates. The Extension Service has worked with producers to help them understand how to take advantage of legume plowdown credits as well as manure application credits on nitrogen. Farm dealers are also putting forth better effort in making proper nitrogen rate recommendations. With no reduction in yields resulting from reduced nitrogen applications, farmers are realizing that over application was commonplace for years. Reducing nitrogen rates assures the possibility of less nitrogen leaching into the groundwater.

The split nitrogen cost-share program was important to the success of helping crop producers reduce nitrogen application rates. With the incentive of being paid $15.00 per acre if they followed Extension Service recommendations, farmers began to realize they could reduce nitrogen rates and yet maintain normal yields. This has resulted in an average nitrogen rate reduction of over 10 lbs per acre from what they had been applying.

2.5.3 Review of Changes in Population, Construction and Other Factors

See Table 2.2.2 for number and size of farming operations located in the watershed. These figures have stayed relatively stable throughout the 10 year period. Some farms have changed hands, some have been taken over by the sons of farmers.

See Form RCWP 4 showing average cost figures for BMP developement for the 1990 construction season. Obviously, labor and materials have increased during the ten year period.

Land use patterns from a conservation standpoint have seen an increase in the use of conservation tillage. It is estimated that approximately 80% of all watershed landusers utilized some form of conservation tillage in 1990. The 1985 and 1990 farm bills have led to the increased use of various conservation practices to ensure eligibility for USDA program benefits.

2.5.4 Impacts and Effects of RCWP

RCWP had an impact on land use in the project area initially and on the surrounding area later when BMPs started to prove themselves. Producers under contract and others who realized the advantages of these management practices shifted to a more conservation-minded style of farming, such as contour farming, conservation tillage etc.

The project had a tremendous impact on water resource management. The split-nitrogen practice and the well water testing provided producers with very important information about how best to utilize nitrate nitrogen supplies in the soil. Also RCWP enabled technicians to develop new methods and standards for animal waste systems and also for the repair of sinkholes.

0 IMPLEMENTATION RESULTS

3.1 Findings and Recommendations

An adequate variety of BMPs must be made available to participants to treat problems identified in the critical areas. Project developers should try to provide more than one BMP to address each problem. One of the early stumbling blocks affecting potential participation in the Garvin Brook RCWP was the rigid requirement that all applicable BMPs must be applied by program participants.

One BMP on our ledger was almost universally shunned by watershed livestock producers. It was also required for all applicable potential participants. Obviously, local participation was limited because of this. What our LCC had to decide was the importance of this BMP verses the success of the project. We decided to no longer make this BMP mandatory and participation increased accordingly.

Another mistake made in our project was made on the first contract we developed. This was our first contract, with our first constructed Agricultural Waste System. This system also ended up being our most expensive project during the entire 10 year period. The cost of this system scared away many of our potential participants. Livestock producers feared that they would be required to develop a similar system at a similar cost. It took many years to erase the stigma of this cost and over the 10 year period we did construct 15 such systems.

3.2 Critical Area Treatment

3.2.1 Definition of Critical Area

The first field application of the Agricultural Non-Point Source Pollution Model (AGNPS) was completed in June, 1985 for the surface water watershed. This program was updated in 1989 by MPCA staff to reflect changes encountered since 1985.

The model was developed by the Agricultural Research Service (ARS) in Morris, Minnesota. It was used to identify specific land area contributions to surface water pollution.

Based on the model, these land areas have been classified into the following priorities:

Critical: Subwatersheds with high and moderate sediment loads and moderate nitrogen and phosphorous loads.

High: Localized high erosion and barnyard "hotspots" outside the critical areas.

Medium: Subwatersheds with either moderate sediment loads or moderate nitrogen and phosphorous loads.

Low: Remaining subwatersheds excluding localized high sediment loads and barnyard "hotspots".

Figure 3.2.1a illustrates critical, high, medium, and low priority areas along with erosion hot spots and barnyard "hotspots".

Approximately 13,059 acres lie within the critical area designation. Of those acres approximately 7,574 acres are cropland of which approximately 3,105 acres are grown to corn.

Groundwater Watershed

The groundwater watershed has been prioritized based on its potential for groundwater contamination to the Prairie du Chien-Jordan aquifer by nitrate-nitrogen.

Figure 3.2.1b indicates the area of high susceptibility to groundwater contamination because of surface and geological characteristics (Winona County Atlas Series, Atlas C-2, Plat 6 of 8, Minnesota Geological Survey).

Similar geology and surface characteristics are found in the Big Springs Basin in Clayton County, Iowa. Data from the hydrologic and water quality investigations in this basin indicate that 90-95% of the nitrate-nitrogen (NO-N) enters the groundwater through either infiltration-base flow or diffuse flow, not directly through sinkholes and abandoned wells, according to George Hallbeg, Chief Geological Studies Division, Iowa Geological Survey. Therefore, the entire cropland area within the hydrogeologic category of high susceptibility is considered the critical priority area when addressing nitrate-nitrogen groundwater contamination. That area which is considered moderate to highly susceptible is considered high priority. There are approximately 12,681 cropland acres that lie within the critical area of the groundwater area.

Figure 3.2.1c illustrates the location of existing areas under contract.

FIGURE 3.2.1a

Critical Area Designation

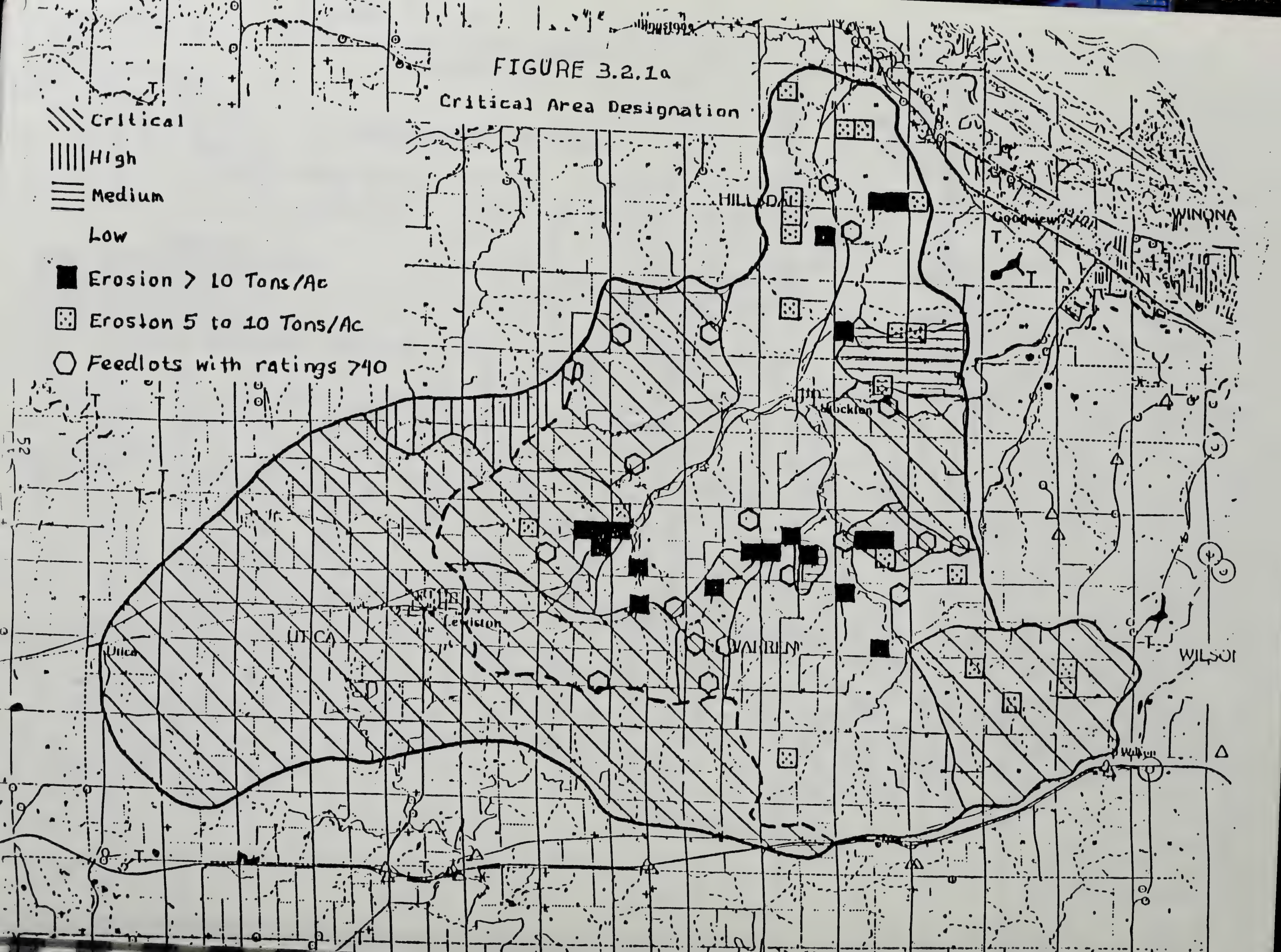


FIGURE 3.2.1b

Susceptibility To Groundwater Contamination

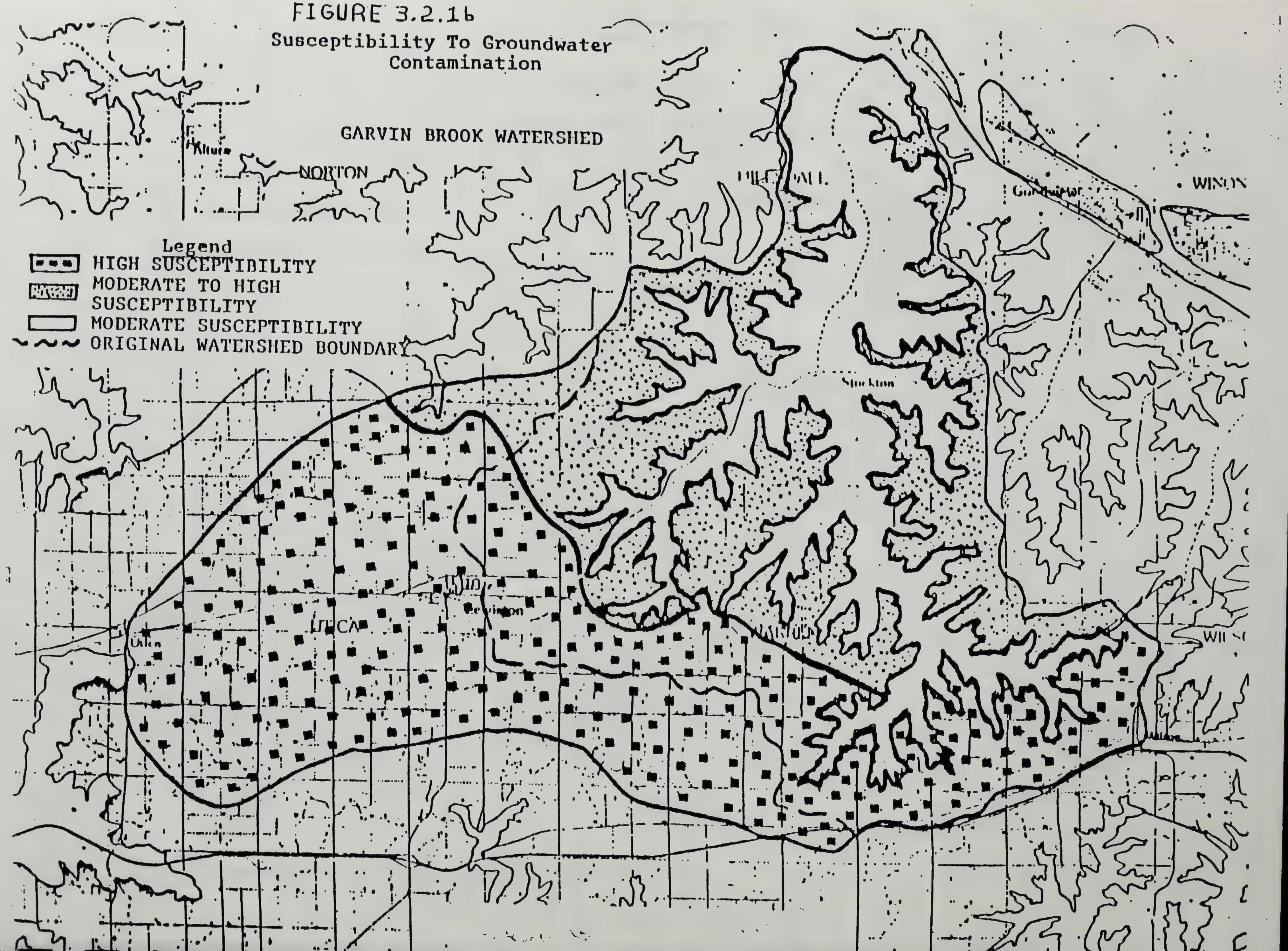


FIGURE 3.2.1c

Areas Under Contract

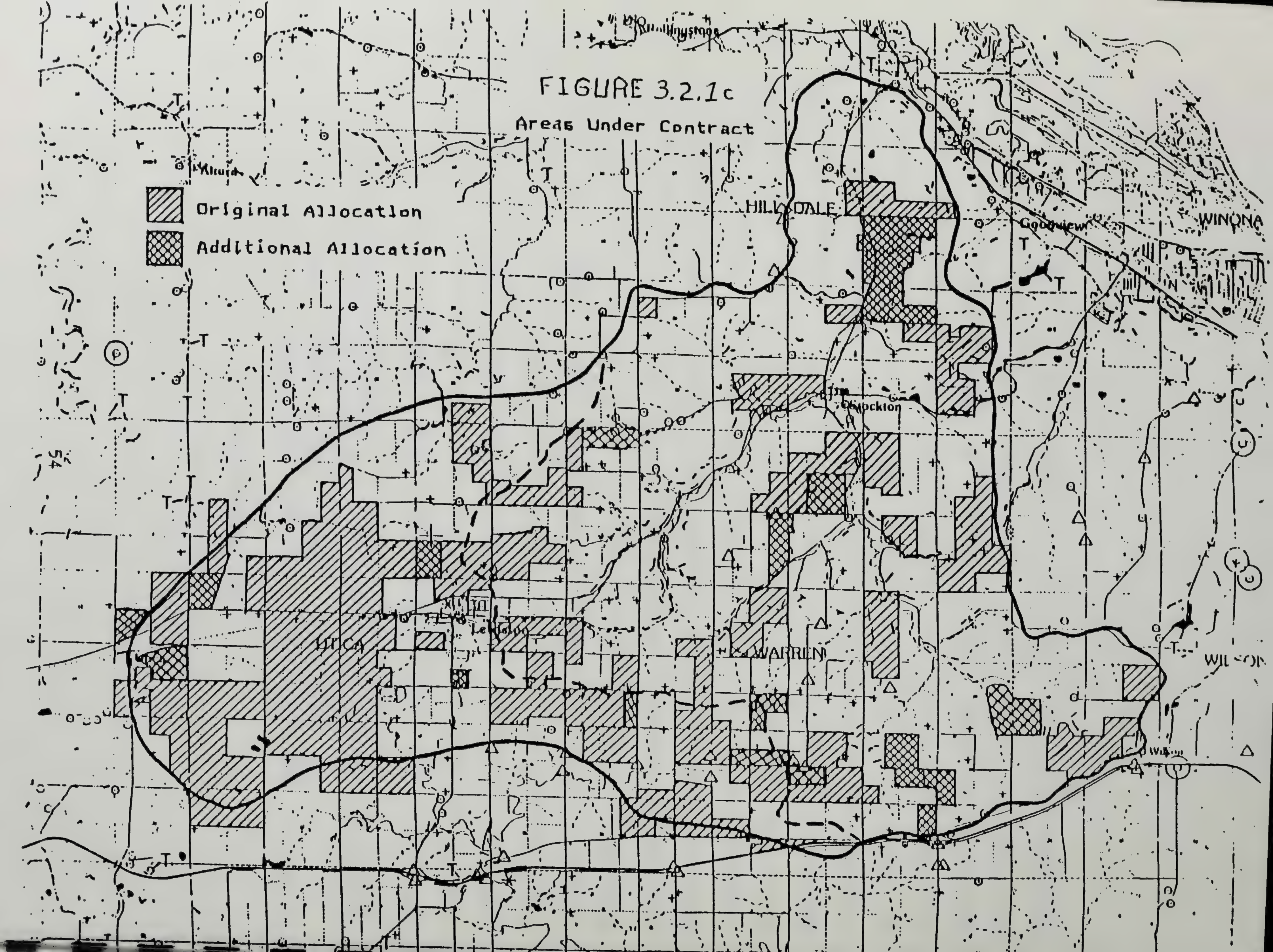


Table 3.2.2

BMP Implementation

Activity	1990 Goal	1990 Proj Accom	1990 N-proj Accom	Cumm Proj Accomp 81-90	Cumm N-proj Accomp	W-shed Accomp To Date	1991 Goal
Contracts #	0	0	-	81	-	81	0
Contract Ac.	0	0	-	14415	-	14415	-
BMP-1 (Ac)	0	0	25.4	455	960.4	1415.4	0
BMP-2 (No)	4	1	0	15	3	18	0
BMP-3 (Ac)	84	13	95.0	559	604	1163	179
BMP-4 (Ft)	0	0	0	14850	0	14850	0
BMP-5 (Ft)	1500	1482	300	3502	3489	6991	1000
BMP-6 (No)	0	0	0	0	0	0	9
BMP-7 (Ac)	1.0	.9	6.2	17.7	27.8	45.5	1.0
BMP-9 (Ac)	3500	3359	807	9403	3437	12840	2348
BMP-10 (Ft)	0	0	0	0	0	0	0
BMP-11(Sink)	22	10	0	28	2	30	14
BMP-11(Well)	0	0	1	1	5	7	1
BMP-12 (No)	0	0	5	5	19	24	0
BMP-14 (Ac)	0	0	2.6	1.9	85.1	87.0	0
BMP-15 (Ac)	7137	4373	0	31643	0	31643	2267
BMP-16 (AC)	7185	4553	0	38083	0	38083	2851
BMP-17 (Ft)	0	0	0	3000	6600	9600	0
BMP-18 (Ac)	0	0	0	0	19.5	19.5	0

3.2.2 Accomplishments

See Table 3.2.2

3.3 BMP Implementation

3.3.1 Description of each BMP and the problem it addresses

BMP 1 Permanent Vegetative Cover

A Purpose. The purpose of this BMP is to improve water quality by establishing permanent vegetative cover on farm or ranchland to prevent excessive runoff of water or soil loss contributing to water pollution.

BMP 2 Animal Waste Management System

A Purpose. The purpose of this BMP is to improve water quality by providing facilities for the storage and handling of livestock and poultry waste to abate pollution that may otherwise result from livestock or poultry operations.

BMP 3 Stripcropping Systems

A Purpose. Stripcropping systems improve water quality by providing enduring protection to cropland causing pollution problems by establishing contour or field stripcropping systems.

BMP 4 Terrace System

A Purpose. The purpose of this BMP is to improve water quality through the installation of terrace system on farmland to prevent excessive runoff of water or soil loss contributing to water pollution.

BMP 5 Diversion System

A Purpose. The purpose of this BMP is to improve water quality by installing diversions on farmland or ranchland where excess surface or subsurface water runoff contributes to a water pollution problem.

BMP 7 Waterway System

A Purpose. The purpose of this BMP is to improve water quality by installing a waterway to safely convey

nonerosive velocities into watercourses or impoundments. The waterway is protected from erosion and reduces pollution through filtering out silt with the establishment of sod cover of perennial grasses, or legumes, or both.

BMP 8 Cropland Protective System

A Purpose. The purpose of this BMP is to improve water quality by providing needed protection from severe erosion on cropland between crops or pending establishment of enduring protective vegetative cover.

BMP 10 Stream Protection System

A Purpose. The purpose of this BMP is to improve water quality by protecting streams from pollutants through the installation of vegetative filter strips, protective fencing, livestock crossings, livestock water facilities, or other similar measures.

BMP 11 Permanent Vegetative Cover on Critical Areas

A Purpose. Permanent vegetative cover on critical areas improves water quality by installing measures to stabilize a source of sediment such as gullies, banks, privately owned roadsides, field borders, or similar problem areas contributing to water pollution.

BMP 12 Sediment Retention, Erosion, or Water Control Structures

A Purpose. The purpose of this BMP is to improve water quality through the control of erosion, including sediment and chemical runoff, from specific problem area, and thereby prevent water pollution.

BMP 13 Improving an Irrigation System, or a Water Management System, or Both

A Purpose. The purpose of this BMP is to improve water quality on farmland that is currently under irrigation for which an adequate supply of suitable water is available, on which irrigation will be continued, and on farmland with a critical area or source that significantly contributes to the water quality problem.

BMP 14 Tree Planting

A Purpose. The purpose of this BMP is to improve water quality by planting trees to treat critical areas or sources that contribute to water pollution.

BMP 15 Fertilizer Management

A Purpose. The purpose of this BMP is to improve water quality through needed changes in the fertilizer rate, time, or method of application to achieve the desired degree of control of nutrient movement in critical areas that contribute to water pollution.

BMP 16 Pesticide

A Purpose. The purpose of this BMP is to improve water quality by reducing pesticide use to a minimum and manage pests in critical areas to achieve the desired level of chemicals contributing to water pollution.

BMP 17 Woodland and Access Road Stabilization

A Purpose. The purpose of this BMP is to provide assistance for repair, reconstruction, and replacement construction of woodland roads that are located in areas sensitive to soil erosion and have a high potential for contributing heavy sediment loads to a water course, creating a water pollution hazard.

BMP 18 Water Quality Improvement Through Woodland Improvement

A Purpose. The purpose of this BMP is to provide water quality improvement, soil protection, and erosion control by properly managing forest land to ensure adequate cover on that portion of the watershed that is unsuitable or undesirable for agriculture or pasture that creates a water pollution hazard.

3.3.2 Acres or Units Treated or Served by Each BMP Implemented under RCWP

See Table 3.2.2

3.3.3 Numbers and Proportion of Project Areas Producers Implementing each BMP under RCWP

Total Contracts - 81

Best Management Practice	Number Used 1981 - 1990	Proportion
BMP1-Permanent Vegetative Cover	25.4	1%
BMP2-Animal Waste System	15	19%
BMP3-Strip Cropping System	559	5%
BMP4-Terrace System	14,850	1%
BMP5-Diversion System	3,502	9%
BMP6-Grazing Land Protection	--------	---
BMP7-Waterway System	17.7	7%
BMP9-Conservation Tillage System	9,403	93%

BMP6-Grazing Land Protection	--------	---
BMP7-Waterway System	17.7	7%
BMP9-Conservation Tillage System	9,403	93%
BMP10-Stream Protection System	--------	---
BMP11-Permanent Cover on Critical Areas	44	30%
BMP12-Erosion or Water Control Structures	5	6%
BMP14-Tree Planting	1.9	1%
BMP15-Fertilizer Management	31,643	100%
BMP16-Pesticide Management	38,083	100%
BMP17-Woodland Access	--------	---
BMP18-Water Quality Improvement Through Woodland Improvement	--------	---

3.3.4 Discontinued BMPs Implemented Under RCWP

When discussing discontinued BMPs, BMP-10 (Stream Protection System) immediately comes to mind. This BMP was very poorly received by watershed landowners. In some cases it was the major holdup in getting a landowner to participate in the project.

The main reason this BMP was such a stumbling block was that the majority of landowners adjacent to the stream corridor were livestock producers. They felt that these riparian areas were needed for pasture and could not be maintained in permanent nonpastured vegetation. They also felt that required fences would be too expensive to maintain.

Contracts in the Garvin Brook Watershed were developed requiring all water quality problems be treated. Until streambank Protection was removed from the list of required practices, this project was at a standstill. The LCC had to decide which was more important, BMP-10 or potentially the success of the entire project.

3.3.5 Changes In BMP Emphasis

Participation began to lag where expensive BMPs such as animal waste systems were needed. The LCC determined that, to keep the project economically viable, the local technical committee must be allowed to be innovative with the design to lower the cost of these previously high priced management practices. Emphasis was shifted from large animal waste systems which were designed to hold all runoff from barnyard areas to systems which utilized grass filter strips and settling ponds.

BMP-15, Fertilizer Management began as strictly an education practice. When the goundwater monitoring data showed high levels of nitrates in numerous wells, the LCC determined that the application of nitrogen to the soil

should be more need specific. At this point the emphasis on fertilizer management education was broadened to include a costsharing practice involving applying nitrogen to the growing crop if and when it was needed and could be utilized by the crop. Most producers in the entire area became very interested in the yield results of crops grown on fields where the split-nitrogen practice was used.

3.4 Contract Modifications and Violations

3.4.1 Total Number of Contracts

The original allocation resulted in 69 RCWP contracts on 6,349 critical acres. The total has been increased to 81 RCWP contracts on 8,631 critical acres. The total acres under contract, both critical and non-critical, is 14,415.

3.4.2 Contract Cancellations and Modifications

A Cancelations - 8

B Modifications - 202

Reasons of Cancellations and Modifications

1. would not agree to follow through with all practices required by the technical agency
2. lost farm
3. sold farm
4. added additional land to contract
5. had new water quality problems arise that required additional BMPs
6. did not follow maintenance requirements
7. added BMP-15 and BMP-16 to existing contracts
8. removed farm from program to participate in other government programs ie: CRP
9. additional funding allocations
10. cost

3.4.3 Contract Violations

Contract violations were minimal in the Garvin Brook RCWP. Every effort was made to explain and clarify with the participant all their responsibilities under the

terms of the contract. If the producer had any misgivings about completing all needed BMPs to specifications, the LCC required that the situation be resolved before the contract was approved. One contract was cancelled and cost-sharing was returned because the participants had changed their mind regarding their animal waste system design.

Animal waste utilization was and continues to be a problem although the LCC hesitates to call it a violation. Producers are required to either inject their liquid manure or work it into the soil immediately after surface spreading. Some years the weather does not cooperate and the ground freezes before the manure holding facility is empty. This necessitates spreading the remainder on frozen ground. The LCC realizes this is beyond the producers control and will not determine it as a violation, but does recommend to the participant ways to minimize pollutant loads.

3.5 Impacts of Other Federal Programs

Other federal programs such as the annual Acreage Reduction Program did have an impact on the implementation of BMPs. During the mid-1980s, when the local agricultural economy was severely distressed, it was difficult for participants to complete practices that required capital input from them. The years 1987-1990 saw an increase in government subsidies to farmers and these helped enable the participant to complete BMPs in a more timely manner.

Also, some contracts were revised to exclude BMPs on acreage that was accepted into CRP. One animal waste system was completed after the participant had removed all dairy animals under the DTP. The system has yet to be used.

3.6 Impacts of State and Local Programs/Regulations

There are many state and local programs having a direct impact on the land treatment and water quality in the Garvin Brook project area. Winona County has an aggressive zoning ordinance that contains strict land treatment regulation. The main component of this ordinance affecting agricultural land is the Soil Loss ordinance. This ordinance is based on a complaint system where offsite damage is adversely affecting an adjacent landowner. Under this local legislation, the county can require remedial action if a justified complaint is filed. The county also implemented a local cost share program directed exclusively at paying a percentage of the more costly BMPs developed by RCWP participants. This is local tax payers dollars directed to implementing

water quality BMPs. It shows real support by local government for our project.

The state of Minnesota has implemented far reaching natural resource programs that are the first of their kind in the county. Some of these programs had a direct impact on our project area.

These programs include the Reinvest in Minnesota Program, a state cost share program for sinkhole treatment and a state costshare program for abandoned well sealing. All three programs were developed to use state money for the treatment of natural resource concerns.

The Reinvest in Minnesota program retires critical agricultural production areas and establishes them to permanent vegetative cover.

The sinkhole treatment program treats critical sinkholes on a priority basis. Many of the principals used in this program were developed in the Garvin Brook RCWP.

The abandoned well program seals wells also on a priority basis. All of the above listed programs are fine examples of how state and local governments can take the initiative and positively address their natural resource problems.

3.7 TECHNICAL ASSISTANCE

3.7.1 Overall Assistance Provided to RCWP Producer Participants

See Form RCWP 4

3.7.2 Types and Amounts of Assistance Provided to Producers Implementing Each BMP

See Form RCWP 4

3.7.3 Lessons Learned

The RCWP was intended to be an experimental program where successes and failures would be identified and analyzed so future water quality projects would not make those same errors.

Many of the BMPs utilized in the Garvin Brook RCWP were also experimental. They were developed using the experience and instincts of the technical staff to address specific water quality concerns. Some failed because they were unacceptable to the perceptions held by watershed landowners. Some had to be modified because of cost or effect. Most adequately treated the targeted

problem and have since been implemented in other parts of the county with similar water quality problems.

Some lessons that we would like to pass on to future water quality projects include:

- Don't lose a potential contract because of one practice unless it is required by law.

- Tailor treatment to site specific problems and landowners needs within technical standards and specifications.

- Contact other projects in the country with similar problems and discuss successes and failures. Technical transfer of information can be invaluable to your project.

0 PROJECT INFORMATION AND EDUCATION ACTIVITIES

4.1 Findings and Recomendations

In order to better educate landowners and farm operators, it is important to conduct plot studies and hold demonstrations. This localizes the effort so it is more meaningful. It is also important in order to call attention to the nitrate/nitrogen concern by actually conducting a well water study. Using water test results, mapping them and then providing information on sound cropping practices, producers could better understand the connection between the cause and the effect.

This raised the awareness of groundwater contamination concerns amongst farmers and non-farmers alike. It helped local officials and policy makers better understand the situation. As a result of University of Minnesota Extension plot work, solutions were found to decrease the heavy reliance on fertilizers and pesticides. Producers discovered they could reduce application rates without lowering yields.

4.2 Cooperative Extension Service Activities

The County Extension office was responsible for the educational component of the RCWP project. It was also responsible for the Technical Assistance in the BMPs of fertilizer and pesticiides management.

Awareness of the RCWP project was generated by holding public meetings on the project. In cooperation with the Minnesota Extension Service a slide/tape presentation was developed at the beginning of the project to explain the program, its purpose and objectives. This was used numerous times in the early years and shown to farm and non-farm audiences. The County Extension office secured a part-time Program Assistant to work on the Project. This individual made individual landowner visits to explain the project. He also wrote a quarterly newsletter which was started in 1983 and sent to all landowners in the project area. This helped to inform them of the RCWP activities and developments. The newsletter was used to announce meetings and tours, and to publish results of plot studies.

The Program Assistant was also responsible for working one on one with those farmers who signed split nitrogen application contracts. Using University of Minnesota recommendations, he was able to help farmers zero in on proper nitrogen rate applications for their corn crops.

Demonstration plots were used to localize farming practice methods that would best fit the project area. Plot work was conducted in cooperation with University of Minnesota Extension Specialists. Demonstrations were conducted on nitrogen rates, rootworm insecticide rates and weed control methods.

The Program Assistant was very helpful to conduct two different well water nitrate/nitrogen studies. One study was a 161 well sampling in the project area to raise the level of awareness and understanding by the public of groundwater concerns. The study ran from 1983 thru 1991 (see Figure 4.2a). The Minnesota Dept of Agriculture analyzed the samples at no cost to the project. All results were mapped with color codes. The second well sampling study was started in 1988 to look at possible seasonal variations in well water nitrate/nitrogen content at 5 week intervals on 12 wells selected according to location, depth, age of well, contruction of well (see Figure 4.2b). These sites are also being used in cooperation with the Minnesota Pollution Control Agency to test for pesticides and other pollutants.

4.3 ASCS Activities

ASCS is the lead agency for RCWP and as such was very much involved with the initial announcement of the project to the public. Newsletters were sent, radio shows and information meetings were conducted and newspaper articles were submitted with the aid of Extension Service and other agencies. After this initial responsibility ASCS assisted with information and education as they continued to answer questions and write news articles, but mainly functioned in an administrative capacity. ASCS updated lists of names of participants and provided funds for dissemination of news releases and the "Garvin Brook Pipeline". ASCS acted as the liaison between the LCC and the SCC.

4.4 SCS Activities

1 Participate on NCC, SCC, and LCC

2 Recommend to ASCS the appropriate agency or group to provide technical assistance for each BMP on a project by project basis. SCS shall coordinate technical assistance.

3 Provide technical assistance for appropriate BMPs

4 Develop and certify water quality plans to CD for critical areas and sources on the farms.

Figure 4.2a

Well Water Sampling Results

Original 80 Wells

Year		3.0		3.1-9.9		9.9
1990	34	44%	35	46%	8	10%
1989	30	37.5%	40	50%	10	12.5%
1988	28	35%	35	43.75%	17	21.25%
1987	30	37.5%	30	38.5%	20	25%
1986	34	42.5%	28	35%	18	22.5%
1985	32	40%	29	36%	19	24%
1984	35	44%	28	35%	17	21%
1983	51	64%	12	15%	17	21%

161 Wells including original 80

Year		3.0		3.1-9.9		9.9
1990	49	30.4%	69	42.9%	43	26.7%
1989	40	24.9%	73	45.3%	48	29.8%
1988	39	24.2%	61	37.9%	61	37.9%
1987	38	23.6%	62	38.5%	61	37.9%
1986	42	26%	60	37%	59	37%

Figure 4.2b

Nitrate Nitrogen Levels
12 Well 5 Week Interval Study

No	Dec 14	Jan 16	Feb 21	Mar 29	May 2	Jun 8	Jul 11	Aug15
1	0.06	0.08	0.08	0.28	0.07	0.07	0.04	0.07
2	0.02	0.06	0.08	0.37	0.08	0.36	0.03	0.08
3	2.40	2.31	1.94	1.80	2.37	1.79	2.41	2.25
4	2.32	2.27	1.77	1.92	2.06	1.64	1.30	1.83
5	3.91	3.61	3.75	3.14	3.65	3.36	3.38	3.38
6	5.84	4.16	3.96	4.60	4.63	5.0	4.51	3.88
7	20.0	23.35	23.76	19.92	16.86	13.05	14.24	20.26
8	13.5	12.44	11.67	14.11	14.10	13.68	13.09	14.03
9	14.9	12.97	11.87	13.05	10.79	10.97	12.66	15.43
10	22.1	22.5	15.74	19.94	20.41	25.74	19.97	23.36
11	10.5	7.77	6.84	7.01	8.92	8.29	8.58	6.48
12	3.75	3.00	2.92	2.91	3.17	2.99	2.45	3.3
AVG	8.27	7.88	7.03	7.42	7.26	7.25	6.89	7.86

5 Assist in project monitoring and evaluation.

6 Assist in providing information to media outlets

7 Write articles for Project newsletters

8 Provide information about project to landowners, units of government and other agencies

4.5 Water Quality Agency Information and Education Activities

MPCA staff has given numerous talks about Garvin Brook monitoring activities during the last ten years, especially since 1988. Presentations were recently made at local (county), regional, state and national meetings, seminars, workshops and conferences. An in-depth Garvin Brook case study was presented to Southeast Minnesota water resource planners and managers in 1991. Information was also recently presented to a state Nitrogen Fertilizer Task Force. For most of the Garvin Brook Presentations made, MPCA staff was invited to speak.

Reports produced by MPCA were also provided upon request and mailed to those involved with water resource policy making decisions. These reports are listed below:

Minnesota Pollution Control Agency. 1982. Garvin Brook Watershed Water Quality - General Monitoring for the Rural Clean Water Program. Annual Progress Report, Division of Water Quality. 129 pp.

Minnesota Pollution Control Agency. 1983. LGarvin Brook Watershed Water Quality - General monitoring for the Rural Clean Water Program. Annual Progress Report, Division of Water Quality. 67 pp.

Minnesota Pollution Control Agency. 1984. Garvin Brook Watershed Water Quality - General Monitoring for the Rural Clean Water Program. Annual Progress Report, Division of Water Quality. 167 pp.

Wall, D.B., S.A. McGuire and J.A. Magner. 1989. Water Quality Monitoring and Assessment in the Garvin Brook Rural Clean Water Project Area. MFinnesota Pollution Control Agency, Water Quality Division. 287 pp.

Wall, D.B., S.A. McGuire, and J.A. Magner. 1989. Nitrate and Pesticide Contamination of Ground Water in the Garvin Brook area of Southeastern Minnesota: Sources and Trends. Minnesota Pollution Control Agency, Water Quality Division. Presented at the NWWA Conferency "Agricultural Impacts on Ground Water Quality." February 20-21, 1990. Kansas City, Missouri. 17 pp.

Wall, D.B. and C.P. Regan. 1991 Water Quality and Sensitivity of the Prairie du Chien-Jordan Aquifer in western Winona County. Minnesota Pollution Control Agency, Water Quality Division. 63 pp.

Vadose Zone Sampling can be beneficial to help determine the effectiveness of BMP implementation within a relatively short time frame. Sampling of both macropore and micropore water is needed.

Testing of many domestic wells in the project area for nitrate can be valuable service that can create water quality awareness and provide another means of contacting land owners about the project. This works especially well when the person collecting samples and reporting results is a person also responsible for project promotion. It is also possible to use such data for tracking nitrate trends.

4.6 LCC/SCC Activities

The LCCs responsibilities included promoting the RCWP on a county or area wide basis as this committee was made up of representatives from all pertinent local, county, state and federal agencies as well as local private citizens. These individuals were able to advance the RCWP as they worked on a day to day basis.

The LCC was also responsible for setting priorities and determining how the requirements of the RCWP could best fit into the Garvin Brook project. The committee met on a periodic basis and was especially important in determining strategy at the beginning of the project. It was important that views of local citizens who sat on the committee could be heard along with the various agency representatives to coordinate strategy and set goals.

The SCC has similar responsibilities at the State level and assisted the LCC with encouragement and direction. The SCC acts as liason between NCC and LCC.

4.7 Inter - Agency Activities

Various agencies worked together to introduce the project to the public at the outset. The LCC determined that the Extension Service, with assistance from the other agencies, would be responsible for the coordination of information and education activities for the project. The Extension Service, SCS, SWCD and ASCS worked very closely together throughout the project, had excellent communications and a good working relationship. As the project moved forward it was important to link up with a number of other agencies such as the County Environmental Health Dept., MN Dept. of Natural Resources and Minnesota

Pollution Control Agency. These agencies were all represented in the LCC. They were involved in numerous activities and events related to the project.

4.8 Public Involvement

The public was kept informed on the RCWP project from the beginning. Public informational meetings were held in the project area to explain it's goals and objectives. Newspaper articles and radio programs helped to create an awareness of the project by the public. At the informational meetings, time was allowed for public input and feedback. Individuals were also encouraged and welcomed to visit the various agencies one on one. The Extension Program Assistant visited landowners farm to farm and received much feedback regarding the views of those people. This feedback was very helpful for the LCC. The well water testing program was highly acceptable by the public. Those whose wells were sampled had special interest in the program and helped to develop some ownership of the RCWP project. Farm Plot cooperators over the years also created special meaning and interest to those people and their neighbors, and friends watched with interest. Each summer plot tours were conducted and each winter educational meetings were held where the public had an invitation to attend. There were also citizen members on the LCC.

4.9 List of Published General Information Material

- See MPCA publication list - page # 4-5
- Garvin Brook RCWP quarterly newsletters
- Brochure on the Garvin Brook RCWP project
- Recommended Allowable Limits for Drinking Water Contaminants published by the MN Dept. of Health
- Clean Water Everybodys Concern, a brochure by the MN Extension Service
- Groundwater Pollution Prevention in SE Minnesota's Karst Region by the MN Extension Service
- Tests and Standards for Drinking Water by the MN Extension Service
- Nitrates in Drinking Water by the MN Extension Service
- Understanding Nitrogen and Ag Chemicals in the Environment by the MN Extension Service
- Pesticides and Pesticide Container Disposal by the

MN Extension Service

- Pesticides: Surface Runoff, Leaching and Exposure Concerns by the MN Extension Service

- Understanding Nitrogen In Soils by the MN Extension Service

- Rinsing Pesticide Containers by the MN Extension Service

- Water Quality for Livestock and Poultry by the MN Extension Service

- Garvin Brook annual report

- Water Quality monitoring and assessment in the Garvin Brook Rural Clean Water Project area

5.0 INSTITUTIONAL RELATIONSHIPS AND ECONOMICS

5.1 Findings and Recommendations

All agencies involved at the local level, whether Federal, State or Local, were part of the group that applied for funding through RCWP for the Garvin Brook watershed. Thus there was a good relationship from the outset. When participation bogged down in the mid-80's, due to one reason or another, there was some finger pointing regarding who should be doing more of this or that. A project coordinator who would not be related to any agency may have solved the problem. As a whole, considering the number of agencies involved, cooperation was very good.

Economic aspects of the project seemed to be mostly favorable. Participants, the general public, and government agencies were all satisfied with the level of cost-sharing and assistance that RCWP provided.

5.2 Institutional Arrangements

5.2.1 Project Administration

The project was administered by ASCS, with the ASCS County Executive Director (CED) and COC making recommendations to the LCC regarding administrative decisions with the aid and advice of other agencies and the Minnesota ASCS State Office Conservation Specialist. Where RCWP-1 Handbook procedure allowed, COC and CED alone made administrative decisions.

5.2.2 LCC/SCC Coordination

The CED and the ASCS State Office Specialist coordinated all activity involving LCC/SCC.In some cases following the initial correspondence, specific technical, I & E, or M & E representatives would continue the coordination efforts.

5.2.3 BMP Maintenance Tracking

BMP maintenance was tracked by the technical agency responsible for the particular BMP. Maintenance problems were first discussed with the participant and if left unresolved were brought to the LCC.

5.2.4 Assessment of Assistance Provided by Federal Agencies

The federal agencies most closely involved with the project at the local level are CES, SCS, ASCS. FmHA and FS were aware of the project at the local level and

offered assistance if needed or required. EPA and ERS were not involved at the local level. The LCC was satisfied with the assistance provided by Federal agencies.

5.3 Economic Evaluation

5.3.1 Installation costs of each BMP and the proportion cost-shared by RCWP

Refer to RCWP-4

5.3.2 Total cost-share assistance provided by RCWP and the amount and proportion going to each BMP

Refer to RCWP-4

5.3.3 Total RCWP project expenditures for technical assistance, financial assistance, and education and Extension

Refer to RCWP-5

5.3.4 Insights or observations about the cost-effectiveness of BMP's in reducing pollutant loadings and how the overall project might have been made more cost-effective.

From a cost-effective standpoint with the largest impact made over the greatest numbers of acres, BMP #9-conservation tillage and BMP#15-Split nitrogen Management were our best practices. The program participants could normally participate in the BMP's with existing tillage equipment to meet our specifications.

For a low cost per acre, BMP15 had an incredible impact on nitrogen use in the project area(see table). This was also an easy practice to sell to farmers from an economic standpoint.

From the short term return standpoint, BMP2, Animal Waste management system was very cost-ineffective. The average cost of our waste management systems was $65,000.00. The majority of our participants could not have justified this practice with just their own resources. This practice can't be looked at from just an economic angle. Many of the systems were implemented on farms where incredible damage to the surface water resouce was taking place. This is also a long term practice and should be viewed over at least a twenty year time frame. Many of the farms with BMPs implemented no longer required commercial nitrogen fertilizer because all needed nitrogen could be recovered form the stored animal waste.

Looking back over the ten years of the project some adjustments had to be made but all BMP's made available were required to fit site specific problems.

5.3.5 Impacts of the BMPs on producers costs and returns

- conservation tillage
  - fuel savings - fewer trips across fields
  - labor savings - fewer trips
  - equipment savings - fewer implements needed

- nitrogen management

  - decreased cost of commercial nitrogen fertilizers because of soil test nitrogen analysis

- Ag. Wastes

  - high initial cost - long term savings because of decreased need for commercial fertilizers

  - decreased wear/tear on equipment - no winter manure spreading

- sinkholes

  - increased tillable area
  - improved water quality

- pesticide management

  - producers were informed about how to scout for potential pest problems so they could treat early
  - saving time, money and yields

5.3.6 Institutional Relationships and Economics

Off-site benefits of RCWP. Impaired water uses exiting before the project which are less impaired by 1990, or are expected to be less impaired in the future.

Benefits within the Garvin brook Watershed can be verified by increased trout populations in Garvin Brook (see Table 5.3.6 MN-DNR standing trout population survey.) They can also be verified by decreased nitrate levels in the test weeks regularly monitored (See Table 4.2a MN Extension well monitoring study.)

To claim offsite benefits outside the project area is harder to verify but we believe there definitely are offsite benefits.

Garvin Brook outlets into Pool 5A of the upper Mississippi River. This area is located within the upper Mississippi river national wildlife and Fish Refuge. Any reductions in sediment, agricultural chemicals and fertilizers will have an obvious positive effect on the fish and wildlife species located in this area.

Also affected would be the trapping, sport and commercial fishing and recreational activities that utilize the area.

We feel that farmers will most readily accept mew practices based on recommendations made by other farmers. The Garvin Brook Project introduced new, innovative practices into the area that were contrary to popular thinking at the time. With the help of some progressive farmers, we were able to get some of these practices started. After ten years we now see these practices being utilized all over the county and are receiving requests for transfer of our technology out of the county to areas with similar problems all over the United States. A lot of this expertise was developed as we went, based on trial and error. Some methods were abandoned but the majority have become accepted engineering and agronomic standards.

Table 5.3.6

FISHERIES DATA

Garvin Brook

Spring adult brown trout numbers and weight 1979-1988

Station	2		3		84HI	
length (ft	595		830		720	
river mi.	1.85*		2.8		3.5	
	no.	lbs.	no.	lbs.	no.	lbs.
1979	21	5.4	65	12.4		
1980	32	11.7	181	36		
1981	11	6.7	84	36.1		
1982	58	13.5	145	36		
1983	198	49.7	557	96		
1984	227	71	277	74.6		
1985	135	38.3	250	50.2	353	101.5
1986	38	11.6	140	60	222	118.2
1987	247	43.3	283	41.2	203	65.2
1988	516	97	511	89	395	99
79-83 avg	64	17	206	43	—	—
84-88 avg	~~223~~	~~52~~	292	63	294	96
79-88 avg	148	35	249	53	294	95

*distance from mouth

Fall fingerling abundance

	no.	lbs.	no.	lbs.	no.	lbs.
1979	5	0.3	315	15.8		
1980	4	0.2	5	0.3		
1981	49	4.9	123	11.1		
1982	175	9.6	472	25		
1983	220	16.5	221	16.6		
1984	130	9.1	222	11.1		
1985	23	1.5	19	1	284	14.2
1986	253	19.9	232	22.8	19	0.8
1987	638	53	258	18	141	9.1
1988	41	2.5	109	5	257	14
79-83 avg	91	6	227	14		
84-88 avg	217	17	180	12	175	10
79-88 avg	154	12	204	13	175	10

6.0 MONITORING PROGRAM DESCRIPTION

6.1 Findings and Recommendations

A long term water quality monitoring strategy should be developed at the very beginning of a project. The strategy should consider:

1) monitoring before, during and after BMP implementation has occurred;

2) monitoring in a way to determine whether water quality goals are met

3) Monitoring overall resource improvement

4) Focused monitoring to assess the effect of specific BMPs.

If long term funding is not secured at the onset of a project, the monitoring strategy should be developed accordingly in a way that would produce meaningful data regardless of future funding levels.

A diagnostic study should be conducted prior to the development of long term plans and implementation of costly BMP's. The Diagnostic study should determine: 1)Pollutants of greatest concern in surface and ground water and specific land uses and area responsible for the water quality degradation, 2) baseline water quality prior to land use changes, 3) ground water recharge area boundaries, ground water residence times and other hydrogeologic characteristics 4) the flow system, especially as it relates to surface and ground water interactions, and 5) vertical variability in water quality within the aquifer.

Very strict field and laboratory QA/QC is needed for long term trend monitoring.

A long term overall project representative is needed to ensure coordination of all aspects of the project, including land use and monitoring activities.

Vadose zone sampling can be beneficial to help determine the effectiveness of BMP implementation within a relatively short time frame. Sampling of both macropore and micropore water is needed.

Land management changes (e.g. types of crops grown, # of livestock produced, set aside programs, conservation programs, etc.) should be monitored throughout project duration.

Testing of many domestic wells in the project area for nitrated can be a valuable service that can create water quality awareness and provide another means of contacting land owners about the project. This works especially well when the person collection samples and reporting results in a person also responsible for project promotion. It is also possible to use such data for tracking nitrate trends.

Quantitative water quality goals should be established prior to implementation of Best Management Practices. Monitoring results can be used to set aggressive but realistic goals.

Since it is often difficult to sort out land treatment effects from climatic effects on water quality, paired watersheds should be considered in future experimental studies.

6.2 CLIMATE/METEOROLOGIC/HYDROLOGIC/LAND USE

Climate

Temperature and precipitation data was recorded by volunteer observers scattered in and around the project area. Data were computerized by the Minnesota Department of Natural Resources Climatology Department. The best continuous records to examine precipitation trends throughout the past ten years were at sites in Lewiston and Winona.

Stream Flow

Gauging stations were established and stage recorders were activated on Stockton Valley Creek at Stockton on February 26, 1982, on Garvin Brook near Minnesota City on March 4, 1982. and on Garvin Brook at Stockton on March 4, 1982. Complete stage record was obtained at all three gaging stations except for August 7-31 at the station Garvin Brook at Stockton. Flow record for that period was estimated on the basis of one discharge measurement and by correlation with flow record from Stockton Valley Creek at Stockton.

A total of 22 current-meter measurements were obtained and used to develop stage-discharge relations for the gauging stations. The measurements showed that stage-discharge relations were stable at the Stockton Valley Creek station and at the Garvin Brook station near Minnesota City. The Stage-discharge relation for Garvin Brook at Stockton was affected by aquatic growth in the channel. However, shifts were well defined by current-meter measurements and good records of flow were obtained.

Between 1982 and 1984, stage measurements were make at all three sites. Continuous stage measurements were obtained between 1984 and 1991 only at the Garvin Brook station near Minnesota City (GB-4.5).

Ground Water Flow

Ground water elevation measurements were not made on a regular basis. Potentiometric surface measurements were made at numerous wells during 1983 for the development of the Winona County Geologic atlas. Measurements were also obtained during 1990. Broadscale ground water flow directions were determined form the potentiometric surface measurements.

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Land Use

A land use assessment of Garvin Brook watershed was made at the onset of the project. Garvin Brook Watershed land use information was also collected during 1984 for AGNPS modeling purposes. A land use assessment was not made for the Ground Water Recharge Area and land use was not carefully monitored for Garvin Brook Watershed between 1985 and 1989.

6.3 SURFACE WATER

Defining Water Quality problems

A total of 14 stream sites (Figure 6.3a) were monitored in Garvin Brook Watershed on June 16, 1981, and June 23, 1982, in order to determine: 1) water quality parameters of greatest concern and 2) variability in water quality at different points in the watershed. Three stations (GB-4.5, GB-11.3, and SV6-1) were sampled 4 to 12 times per year during 1982 and 1983.

Routine Stream Sampling

Monthly sampling and analysis of 18 parameters occurred at one Garvin Brook site (GB-4.5) between 1981 and 1991. This site is located 4.5 miles upstream from the confluence of Garvin Brook and pool 5A of the Mississippi river. The purpose of this sampling was to provide

information useful for tracking long term base flow trends at a site that would best represent watershed conditions and where continuous stage-discharge information was available. The parameters analyzed are listed below. Routine stream sampling was not conducted at any other sites between 1984 and 1991.

Nitrite + Nitrate (NO2NO3)
Total Suspended Solids (TSS)
Temperature (Temp)
Turbidity (TURB)
Conductiviity (COND)
Dissolved Oxygen (DO)
Biological Demand (BOD)
Chemical Oxygen Demand (COD)
pH
Total Solids (SOL00)
Total Volatile solids (SOL05)
Suspended Volatile Solids (SOL35)
Organing Nitrogen (OrGN)
Ammonia Plus Ammonium (NH3NH4)
Nitrite (NO2)
Kjeldahl Nitrogen (KJEL)
Total Phosphorus (TP)
Total Organic Carbon (TORGC)

Storm Event Monitoring

The original intent of runoff event monitoring was to define the relation ship between discharge and sediment nutrient transport for various snowmelt and storm events. However, due to very few significant runoff events and difficulties in manually obtaining and difficulties in manually obtaining storm event samples during 1982 and 1983, the first major runoff events were not monitored until June 7-8 and June 16-17, 1984. Samples were collected at two sites during the 1984 storms. As a result of funding decreases and an increased emphasis on ground water, storm event sampling was discontinued between 1984 and 1988, and the original objective of this monitoring never was net.

During May 1988, automatic water samples were installed at two sites on Garvin Brook. The primary objective for this monitoring was to generate additional storm event data that could be used to verify the computer model AGNPS. Two storm events were monitored in 1989 (April 24-25 and May 24).

Trout Surveys

The Minnesota Department of Natural Resources (MDNR) has been conducting brown trout surveys at two control sites on Upper Garvin Brook since 1979. These"control" sites

are areas which are not stocked and where no trout habitat improvement projects have occurred. Brown trout are the primary species of trout found in these reaches of the stream. The trout shocking sites are located on Garvin Brook 1.85 and 2.8 miles upstream from the confluence of of Stockton Valley Creek at Stockton. Lenghts of the stream segments that are stocked and sampled are 595 and 830 feet at the two sites. The number of trout, total pounds of trout, and fingerling abundance are determined in the summer and fall. Spring adult trout numbers and spring pounds of trout were used for trend analysis because spring populations are less influenced by fishing pressure than fall trout numbers. Fall fingerling abundance was used in the trend analysis to minimize the influence that winter severity has on the fingerling abundance. See Table 5.3.6.

6.4 SOIL PROFILE (VADOSE ZONE)

Soil water samples were taken at depths between 2 and 22 feet during 1988 and 1989 in order to:

Determine whether high concentrations of nitrate and pesticides were moving through the rooting zone in fields that had been under RCWP contract for two to four years.

Evaluate nitrate and pesticide contributions from agricultural fields, sinkholes, grassland, woodland and ponds in an effort to better characterize the major sources and pathways of ground water contamination.

Twenty-nine soil water samplers were installed at 15 sites and sampled two to eight times. Four different types of soil water samplers were used, including stainless steel pressure vacuum lysimeters PVL, BATr monitoring systems, glass block percolate lysimeters and wick Percolate sysimeters (Table 6-1). Water samples were analyzed for pesticides, nitrate and general water chemistry.

In addition to the soil water samples collected from lysimeters, one-time soil samples were taken and analyzed at sites (sinkholes, woodland, pasture, and feedlot runoff areas).

6.5 GEOLOGIC INVESTIGATIONS/SITE SELECTION

Geologic Atlas

During 1983 and 1984, the Minnesota Geological Survey developed a geologic atlas for Winona County, the second county geologic atlas prepared in the state. The atlas included plates on bedrock geology, geologic resources, geology and well construction, susceptibility of the ground water system to pollution, bedrock hydrogeology, and sinkholes and sinkhole probability, The atlas was very beneficial for defining ground water flow, showing locations of sinkholes, and indicating areas most vulnerable to contamination. Based on the results from the atlas, the boundary for the Garvin Brook RCWP Area was redefined to include the entire ground water recharge area for Garvin Brook Watershed.

Lysimeter Installation

A drilling rig and flight auger were used to conduct exploratory drilling before lysimeters were installed. One of the purposes in drilling was to find sites where saturated or near saturated soil conditions existed so that samples could be taken with BATs and Pressure Vacuum Lysimeters even under drought conditions. Another reason for sampling in saturated or perched conditions was to obtain water samples more representative of micro- and macropore movement. Saturated or perched conditions were found at several sites where low permeability till or bedrock existed. These sites were difficult to locate and of limited extent. The perched water sites are non-aquifer settings and water content and pore pressure varied over the study period.

6.6 GROUND WATER

Original Network

The original ground water monitoring network consisted of 15 wells and 3 springs located in Garvin Brook Watershed. The wells were chosen to represent each of the aquifers used in the watershed, and included 2 Prairie du Chien wells, 2 Jordan wells and 2 Jordan springs, 9 Franconia-Ironton-Galesville (FIG) aquifer wells and 1 FIG spring, and 2 Mt. Simon wells. THese sites were sampled for a variety of parameters on a quarterly basis in 1982 and once in 1983, 1984 and 1987.

This network proved to be somewhat useful for characterizing water quality differences between aquifers, but was not adequate for evaluating ground water response to RCWP land use changes. Only two

of the eighteen sites had nitrate in excess of 3 mg/l and only one site had detectable pesticide concentrations in 1982. Most of these wells were withdrawing pristine ground water.

Annual Nitrate Sampling

In 1983, the Minnesota Department of Agriculture originated a project to sample domestic wells annually for nitrate-nitrogn (NO3-N). The original purpose was to raise the awareness of people in the Garvin Brook RCWP project area to current and potential water quality problems. Eighty domestic wells were selected to uniformly cover the Garvin Brook Watershed. The sampling was conducted each year (usually in June) by the Winona County Extension RCWP Program Assistant. Beginning in the summer of 1985, 65 additional wells in the Ground Water Recharge Area were added to the program. Nineteen more wells were added in 1986, for a total of 161. Many of the 161 wells were still being sampled in 1991; however, some well owners withdrew from the sampling program.

The data set created from this annual nitrate sampling is the most useful data set for measuring ground water nitrate response associated with the Garvin Brook RCWP. The sampling program also heightened public awareness of ground water contamination problems and provided additional chances to discuss RCWP with landowners.

Recognizing the limitations of trends associated with annual sampling, Winona County Extension initiated a program in 1988 to sample twelve wells at five-week intervals. The program was designed to assess short term nitrate concentration variability and extrapolate this information for the annual sampling program data interpretation.

Pesticide Monitoring

Due to increasing concerns about pesticides in ground water, the MPCA sampled 10 high nitrate wells in the RCWP Ground Water Recharge Area for alachlor and atrazine in 1985. Four wells tested positive for atrazine and five tested positive for alachlor. As part of a statewide pesticide monitoring effort, the Minnesota Department of Agriculture (MDA) began sampling these same 10 wells in 1986 for over eighteen different pesticides. Quarterly sampling of these 10 wells by MDA continues through 1988, with four wells sampled through 1991. The primary purpose for sampling these wells for pesticides was to determine temporal variability of pesticide concentrations in this karst setting. In an effort to supplement the MDA data and further characterize the nature of ground water pesticide contamination in the Garvin Brook RCWP area, MPCA began sampling twelve wells during 1988

for over eighteen pesticides. These wells were the same twelve wells sampled for nitrate every five weeks by Winona County Extension. These wells were sampled for pesticides six times between February 1988 and May 1989. From the combined MDA and MPCA monitoring sufficient baseline pesticide concentration data was established.

Other Miscellaneous Ground Water Monitoring

Most wells sampled for nitrate or pesticides by MPCA were also sampled for other major ions. The purpose for this sampling was: 1) to add an extra measure of QA/QC through cation/anion balances, 2) assess ground water contamination of other parameters such as chloride and sulfate, 3) provide information for future geochemical modeling, and 4) compare water chemistry among aquifers and spatial variability within given aquifers.

A "spin-off" monitoring project was conducted by the MPCA between 1989 and 1991. Fifty-four wells were sampled in the Garvin Brook Ground Water Recharge Area and wells west of this area as part of a broad scale project assessing geologic sensitivity of ground water resources in Minnesota. One of the reasons for choosing western Winona County to be one of the aquifer study areas was that much information was learned about the ground water system/quality in the RCWP area from work conducted by MPCA, MGS, MDA, and Winona County Extension between 1981 and 1989. Therefore, this project was designed, in part, to build upon existing data.

While much information was obtained from past studies, a lot of the water quality data in past work was either from: 1) wells that had very little known about well construction and underlying geology; 2) wells which were in aquifers too deep to reflect recent land use conditions; or 3) vadose zone sampling.

By sampling wells with associated well logs, the major goals and objectives of this spin-off study (conducted from 1989 and 1991) were to:

1. Determine the variability of well water chemistry and quality withdrawn from the Jordan Sandstone and determine the geologic, hydrologic, and other factors controlling the observed variability in the study area;

2, Characterize differences between water withdrawn from the Prairie du Chien Dolomites Formation and the Jordan Sandstone Formation, including nitrate concentrations, general chemistry and residence times; and

3. Assess the sensitivity of the Prairie du Chien-Jordan Aquifer to contamination in this area of the state, and compare ground water monitoring results to sensitivity rankings; and

4. Assess the potential for denitrification to occur in the Prairie du Chien-Jordan aquifer in the study area.

During the 1989 to 1991 project, ground water residence times were assessed from tritium and carbon 14 isotope data. This data is useful for obtaining very general estimates of the lag time between land use changes and ground water response.

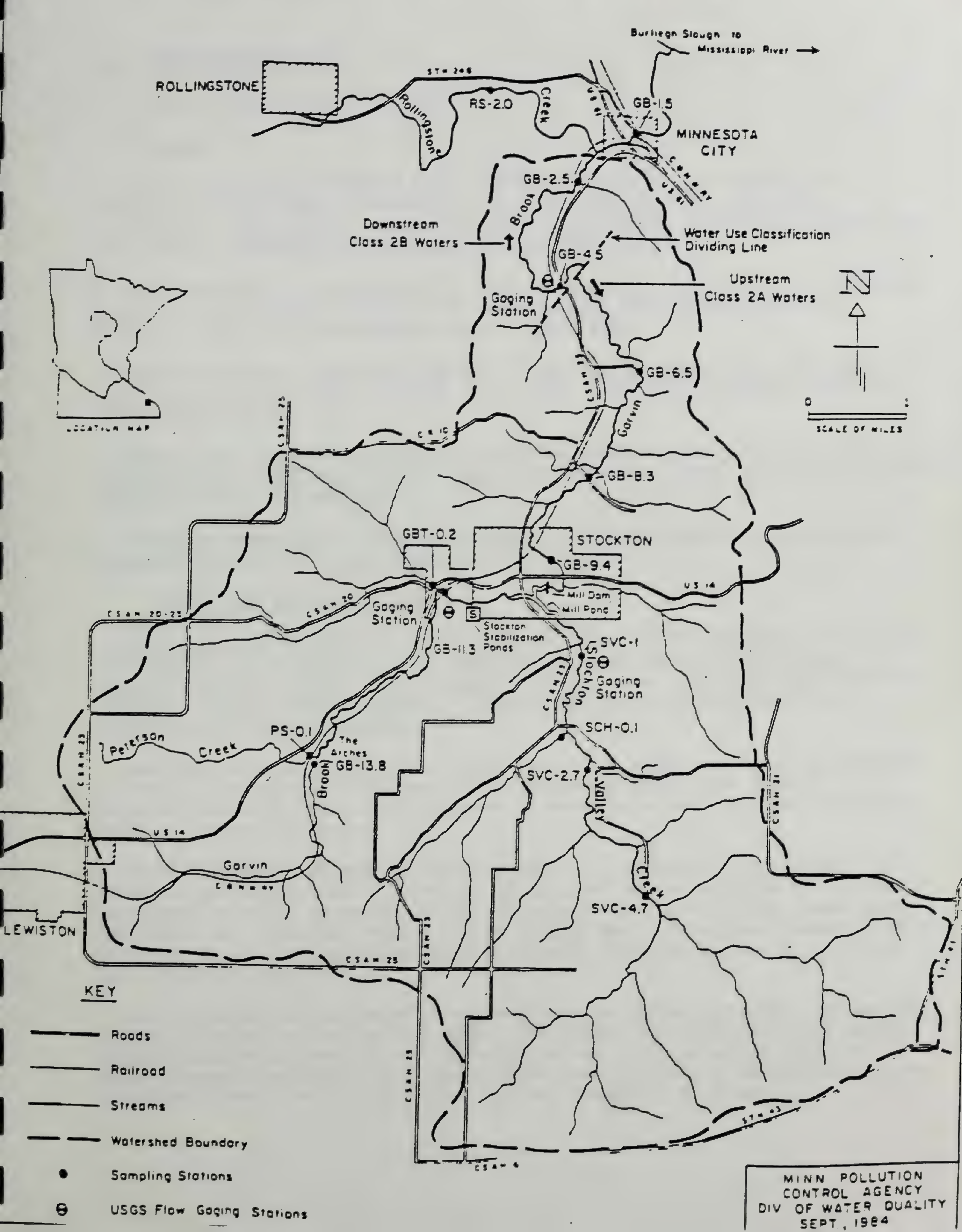
6.7 LAND USE/LAND TREATMENT

Land use and land treatment were monitored using various methodology available to the agencies responsible for the Garvin Brook RCWP. SCS monitored land treatment practices through follow-up maintenance reviews. Annual status reviews were also good ways of monitoring land use and land treatment trends.

The 1985 Food Security Act provided a vehicle for SCS to review land use in the watershed. Most RCWP participants were also participants in the USDA programs and thus were required to be actively applying an approved conservation plan by 1990 under the cross-complience provisions of the above mentioned act. This provided excellent data for monitoring land use and land treatment in the watershed.

The annual Feed Grain Acreage Reduction Program made available excellent annual cropping data for program participants. Information on different crop acreages was readily available. Also, ACP practices completed in the program area as well as conservation practices installed without cost-sharing were listed with the BMPs completed under RCWP to monitor land treatment progress.

FIGURE 6.3a GARVIN BROOK WATERSHED SURFACE WATER STATIONS



7.0 MONITORING RESULTS

7.1 Findings and Recommendations

Stream

- Routine sampling of Garvin Brook 4.5 miles from its mouth showed no significant improvement in baseflow conditions between 1982 and 1990. Significant improvements observed in several parameters from 1982 to 1985 were followed by concentration increases between 1987 and 1990.

- AGNPS modeling of storm event delivery to the mouth of Garvin Brook predicted 17 percent reductions in TSS and 10 to 20 percent reductions in nutrient delivery resulting from implementation of RCWP BMPs.

- Sediment delivery measured from all 3 major storm events that were monitored (1.65 to 2.2 inches precipitation) was within 33 percent of AGNPS predicted sediment deliveries.

- Brown trout populations appear to have increased between 1980 and 1988 at two control sites. Declines in both fingerling and adult brown trout abundance have occurred during 1989 and 1990.

- Future studies should focus monitoring in critical subwatersheds and use biomonitoring to aid in assessing long-term trends.

Vadose Zone and Ground Water

- Nitrate concentrations at 4-5 foot depths below four cornfield sites was in the range of 20 to 50 mg/l, even after 2-4 years of using RCWP nitrogen management BMPs. Either more stringent measures were needed to reduce nitrate leaching or more time was needed to observe the full benefits from the implemented nitrogen management BMPs.

- Leaching of nitrate below fertilized land was a major source of ground water nitrate. Only certain sinkholes, those receiving runoff from heavily fertilized/manured fields, are believed to contribute much nitrogen to ground water in the studied area.

- About 40 percent of over 160 wells sampled in the entire project area had nitrate-N concentrations in excess of 10 mg/l during the mid-1980's. A greater percentage of wells exceeding 10 mg/l nitrate-N were found in the Ground Water Recharge Area. This was believed to be largely due to the great number of wells developed in the fractured carbonate Prairie du Chien Formation in the Ground Water Recharge Area.

- From 38 wells pulling water from the Prairie du Chien formation, the median nitrate-N concentration was 11.7 mg/l. The Jordan formation wells had varied, but generally much lower nitrate-N concentrations, with a median of 2.2 mg/l. Wells in deeper aquifers, below one or more confining units, were found to have consistently very low nitrate concentrations (usually < 0.01 mg/l).

- Statistical analysis of annual nitrate data from 111 wells with nitrate-N greater than 3 mg/l showed 79 percent of all wells with no significant ($p \leq 0.10$) nitrate trend with time. When considering only wells with nitrate-N levels between 3 and 10 mg/l, slightly more wells had significant increasing trends than decreases. However, when considering only wells that had over 10 mg/l nitrate-N during the first few years of sampling, 16 (31%) wells had statistically significant ($p \leq 0.10$) decreasing trends and no wells had significant increases with time.

- No correlation was found between nitrate concentrations and proximity of domestic wells to sinkholes. Nitrate concentrations in water moving to ground water via sinkholes varied greatly, being very low in sinkholes surrounded by hay, grassland, or woodland and very high in sinkholes surrounded by corn fields.

- A comparison of nitrate concentrations determined from water collected at the same places and times at three different laboratories showed significant and consistent differences in reported concentrations. Strict QA/QC procedures are imperative for long-term trend studies.

- Of 21 domestic wells sampled in 1988 and 1989 for 18 to 25 different pesticides, 16 (76 percent) had at least one detection of the herbicide atrazine. All but two of the wells had detections less than the drinking water standard of 3 ppb, and many of the detections were in the range of 0.05 to 0.20 ppb. The only wells with detectable pesticides other than atrazine were the same two wells with atrazine above 3 ppb. These two wells are Prairie du Chien (PDC) wells and are located on the eastern fringes of the city of Lewiston.

- Relatively high concentrations of four pesticides were found to be entering sinkholes just south of Lewiston. These pesticides were believed to originate from the city of Lewiston, where very high pesticide concentrations were found in soils around commercial pesticide applicator facilities. Effects from pesticide management BMPs may be undetectable in some areas due to "point" source related pesticide problems.

- Evidence of some leaching of pesticides (mostly cyanazine and atrazine) was found below cropland.

- Of 143 wells sampled for coliform bacteria in June 1989, 20 percent had detectable bacteria (at least 2.2 MPN/100 ml). Coliform bacteria were found in certain wells from all aquifers, but were least prevalent in Jordan wells.

- Vertical and lateral variability in water quality and residence times may only be understood when detailed geologic information is available. Relying on well driller's logs alone was insufficient for accurately defining geologic sensitivity in this region.

- Dissolved solids concentrations are generally lower in Jordan Formation wells than PDC wells. Water from both formations has low chloride, sulfate, and total dissolved solids compared to secondary drinking water standards and concentrations found in several other Minnesota aquifers.

- Denitrification is likely to be causing a reduction in nitrate in parts of the PDC-Jordan aquifer. Due to the likelihood of denitrification in the deeper part of the Jordan Formation, and the relatively low residence time (< 37 years) of water in the PDC and much of the upper Jordan, the nitrate situation should significantly improve in the PDC-Jordan aquifer (Winona Co.) within one generation following reductions in nitrate loading into the aquifer.

7.2 Climate/Hydrologic

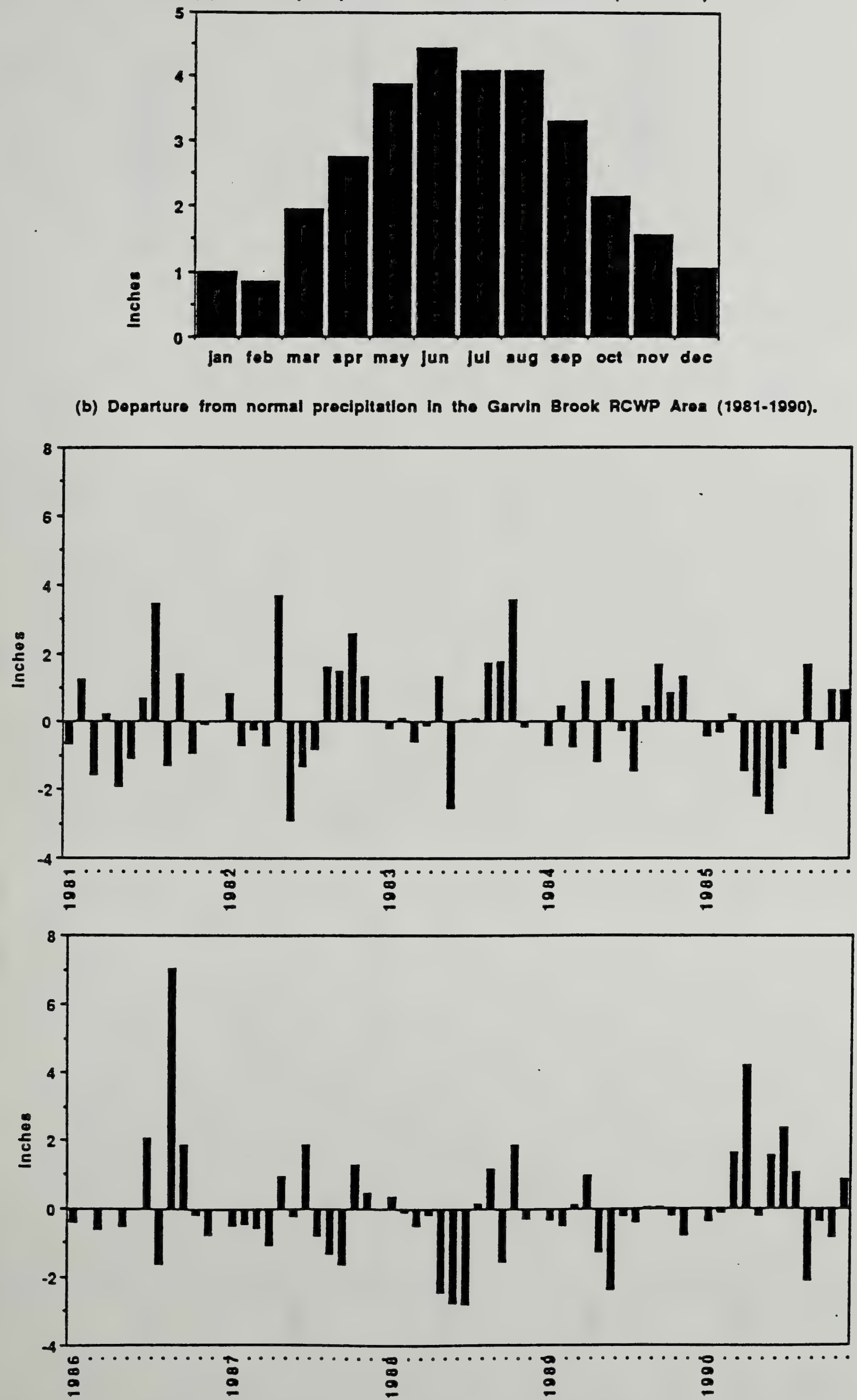
Monthly precipitation departures from normal between 1981 and 1991 is shown in Figure 7.1. Precipitation was greater than average in 1981 (+3.3"), 1982 (+2.7"), 1983 (+5.2"), 1984 (+2.0"), 1986 (+8.0"), 1990 (+7.8"), and 1991. Precipitation was less than average in 1985 (-5.0"), 1987 (-1.0"), and 1988 (-6.8") and 1989 (-4.2"). There were two extended periods of precipitation extremes during the project duration. From 1981 to 1984, total precipitation was 13.2 inches greater than normal. Between 1987 and 1989 total precipitation was 12.0 inches less than normal.

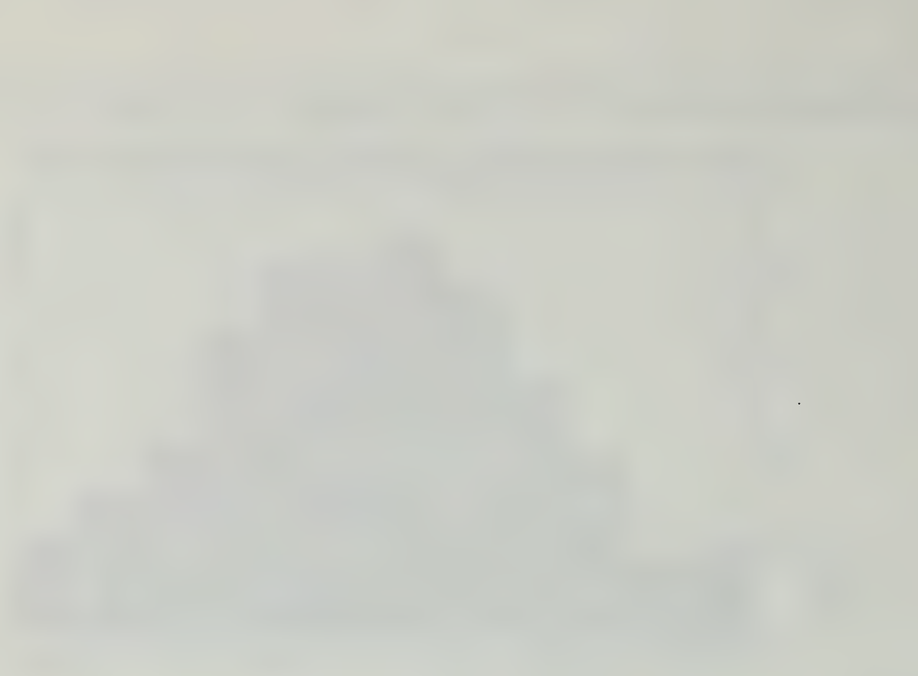
Baseflow, while relatively low in 1982, remained above 40 cfs between 1983 and 1986 at station GB-4.5 (Figure 7.2). This period was followed by decreased baseflow (27 to 40 cfs) between 1987 and 1990, perhaps in response to the dry 1987-1989 conditions. Ground water flow is described in Section 7.5.

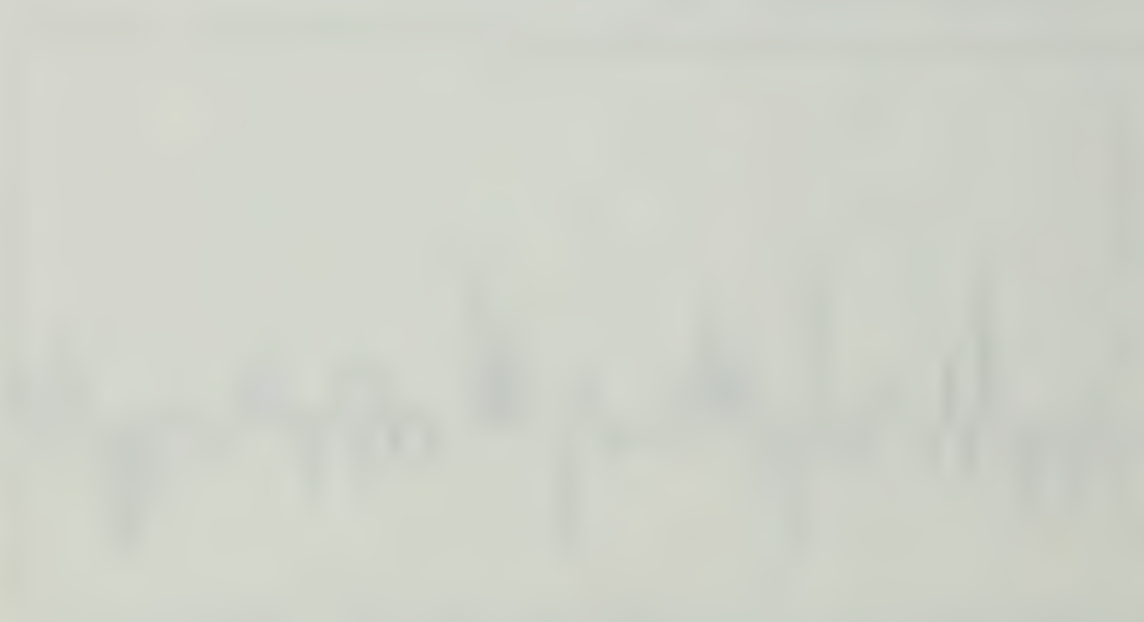
Figure 7.1: Average precipitation in Winona and depature from normal in the Garvin Brook RCWP Area.

(a) Normal precipitation in Winona, Minnesota (1951-1980).

(b) Departure from normal precipitation in the Garvin Brook RCWP Area (1981-1990).







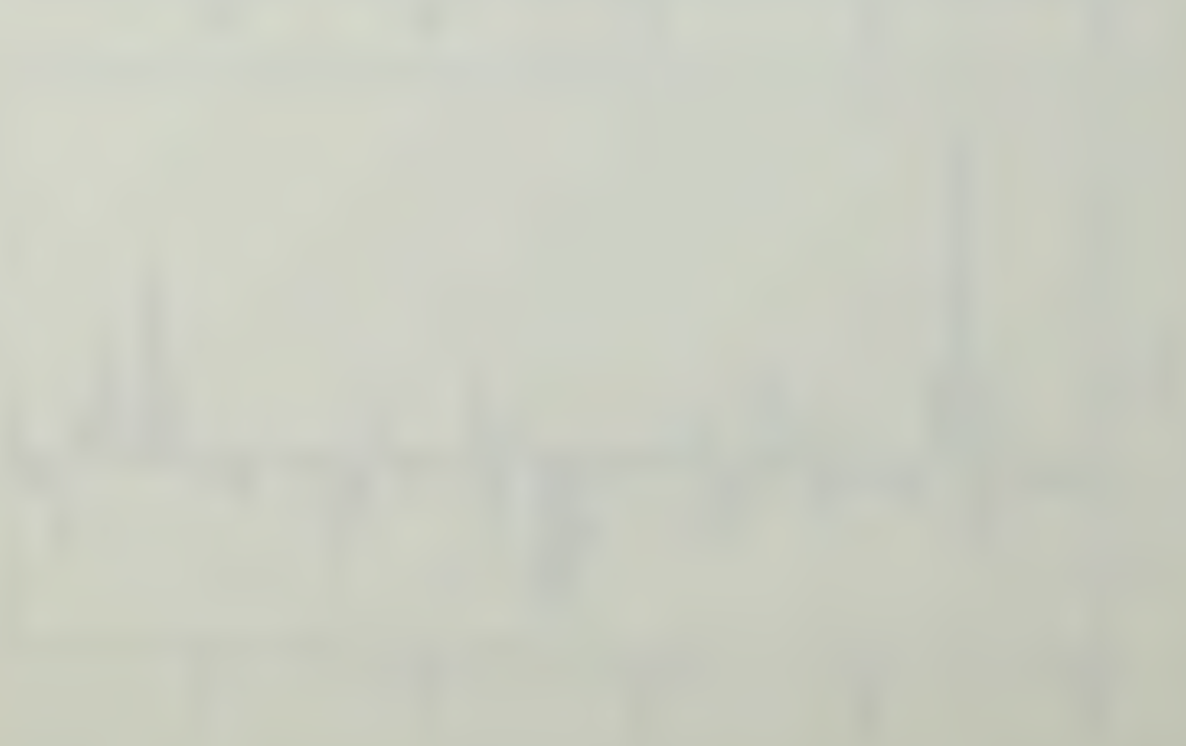
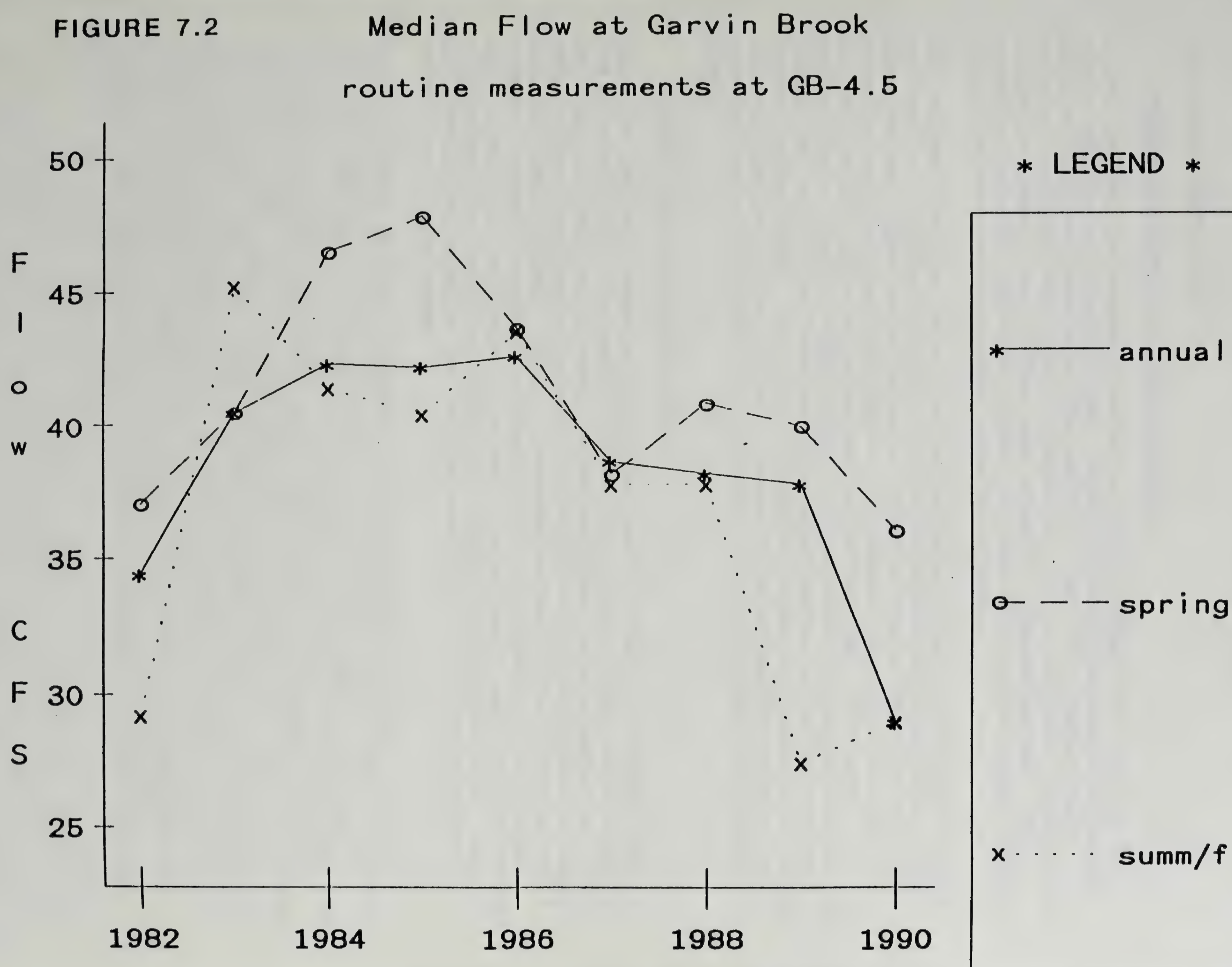


FIGURE 7.2



Median Flow at Garvin Brook
routine measurements at GB-4.5
Flow CFS
50
45
40
35
30
25
1982
1984
1986
1988
1990
* LEGEND *
annual
spring
summ/f

7.3 Surface Water Results

Defining Surface Water Quality Problems

In 1981 and 1982 the parameter having the highest percent of violations in routine sampling was fecal coliform. Fecal coliform violations of 92 percent and 38 percent were reported at stations GB-4.5 and SVC-1, respectively. Turbidity violations were 29 and 33 percent at the two stations. Water quality problems at eleven other stations were excessive suspended sediment, high turbidity, bacterial contamination and low levels of dissolved oxygen (diurnal fluctuation resulted in dissolved oxygen violations).

High sediment loadings, bacteriological contamination and low dissolved oxygen continued to be problems in 1983 at the three routine monitoring sites. Most parameters had higher concentrations at high flow than at base flow and higher concentrations downstream than upstream. Nitrate+nitrite is an exception to this pattern with higher values at baseflow and upstream. The higher nitrate+nitrite levels upstream is due to ground water discharging from the high nitrate Prairie du Chien formation in the upper reaches of Garvin Brook and Stockton Valley Creek. Ground water discharge further downstream is from deeper aquifers with low nitrate. Higher nitrate+nitrite at baseflow suggests that concentrations of nitrate+nitrite are greater in ground water than surface runoff.

Stream - Routine Sampling Trends

Annual and seasonal parameter medians were used to observe trends from 1982 to 1990 at site GB-4.5. The use of medians in the trend analysis should minimize the impact that extreme or unusual values would have on data evaluation. These median values (from samples generally collected monthly) should best represent base flow condition water quality. Suspended sediment during this time should represent sediment brought into suspension from the stream bottom or stream bank. A reduction in erosion during small storms should result in less sediment in the stream that would be available for transport during base flow. Large runoff events may actually tend to flush some of the previously deposited sediment out of the stream.

Medians for each parameter concentration were calculated for the whole year (each year between 1982 and 1990), for just the spring months (March-June, each year 1982-1990) and for summer and fall months (July-November, each year 1982-1990). As reported in Wall et al. (1989), for the period 1982 through 1988 statistically significant improvements were observed for summer/fall total suspended solids, turbidity, dissolved oxygen and phosphorus. In addition fecal coliform bacteria levels were much lower than during the first two years of study. However, when years 1989 and 1990 were added to the trend analysis, no statistically significant positive or negative trends were observed for all 19 parameters (regression analysis for normally distributed data and Kendalls tau for non-normally distributed data). Median TSS, turbidity, T. phosphorus and fecal coliform levels are shown in figures 7.3 to 7.6. Levels of many parameters were high at both ends of the study (1982-1983 and 1989-1990) and lower in the middle years (1984-1988).

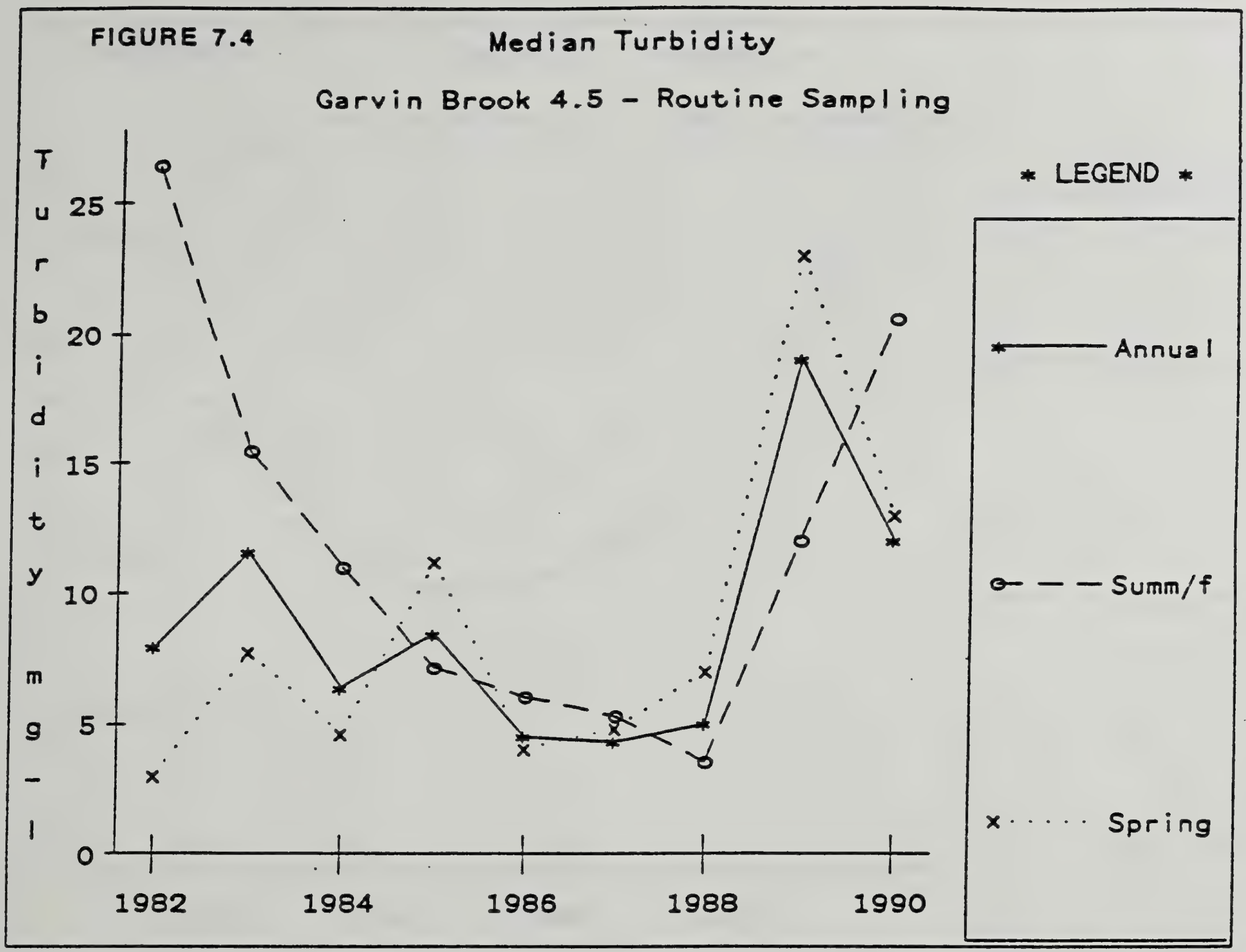


FIGURE 7.4
Median Turbidity
Garvin Brook 4.5 - Routine Sampling
Turbidity mg-l
0
5
10
15
20
25
1982
1984
1986
1988
1990
* LEGEND *
Annual
Summ/f
Spring

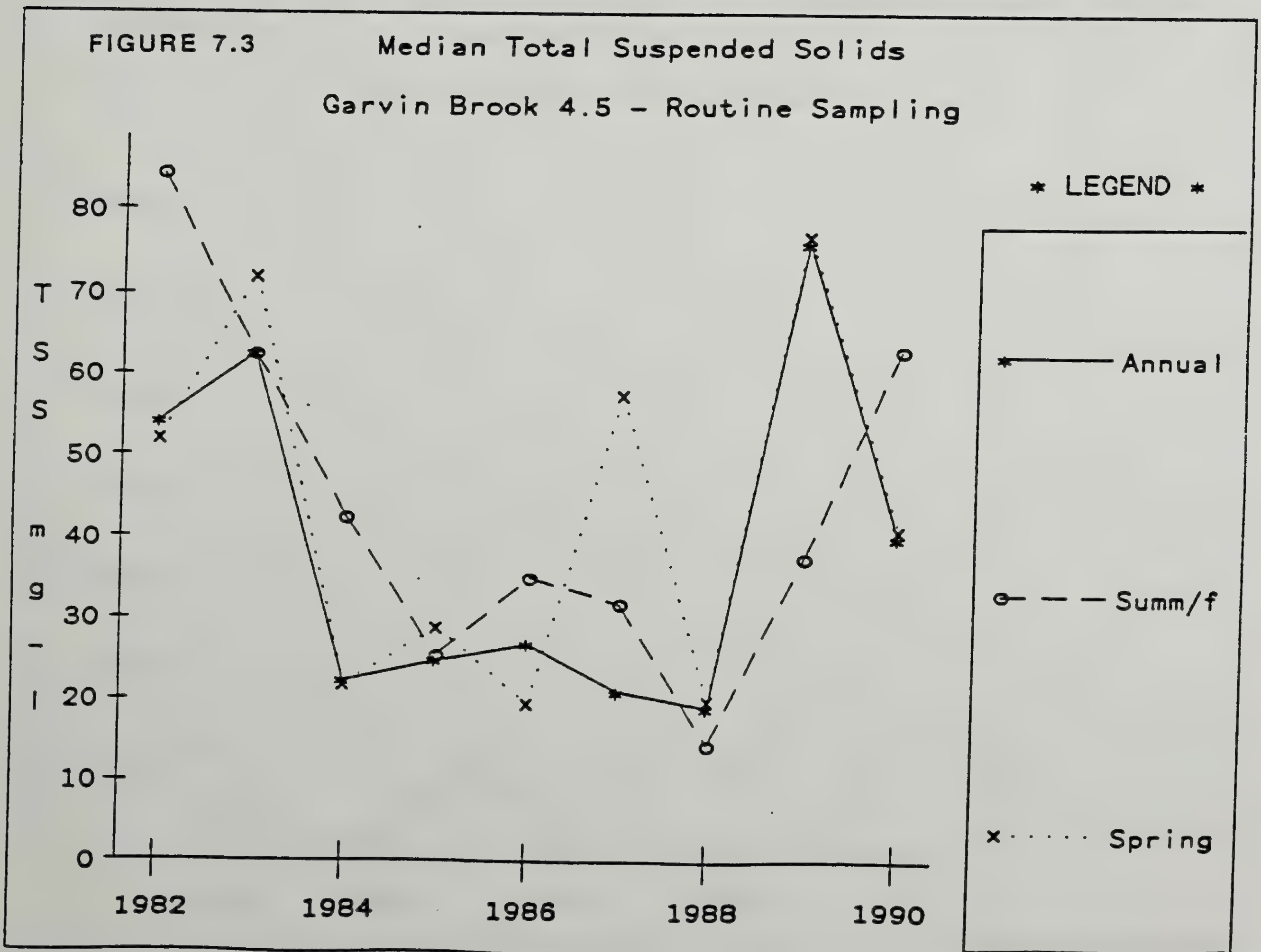


FIGURE 7.3
Median Total Suspended Solids
Garvin Brook 4.5 - Routine Sampling
TSS mg-l
0
10
20
30
40
50
60
70
80
1982
1984
1986
1988
1990
* LEGEND *
Annual
Summ/f
Spring

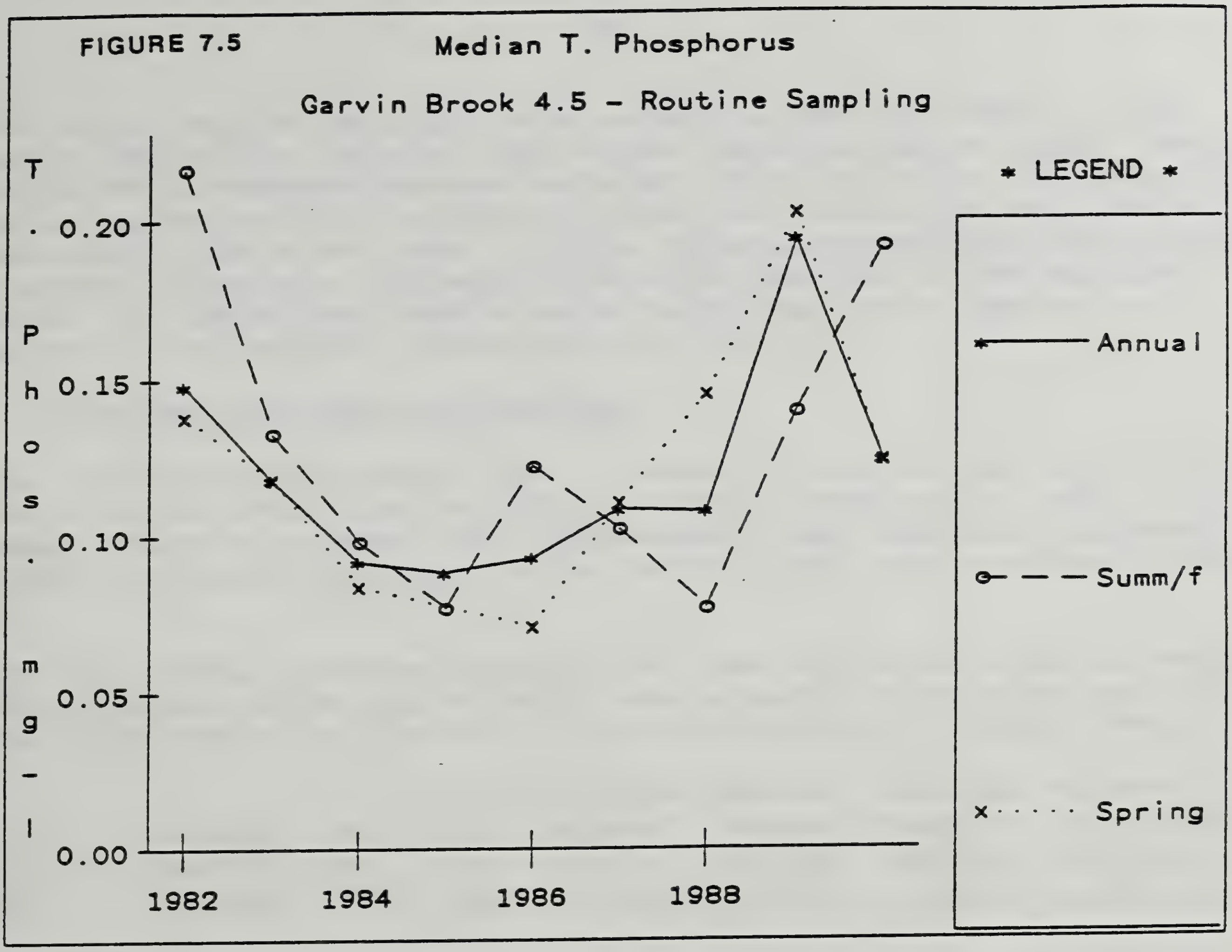


FIGURE 7.5
Median T. Phosphorus
Garvin Brook 4.5 - Routine Sampling
T. Phos. mg-l
0.20
0.15
0.10
0.05
0.00
1982
1984
1986
1988
* LEGEND *
Annual
Summ/f
Spring

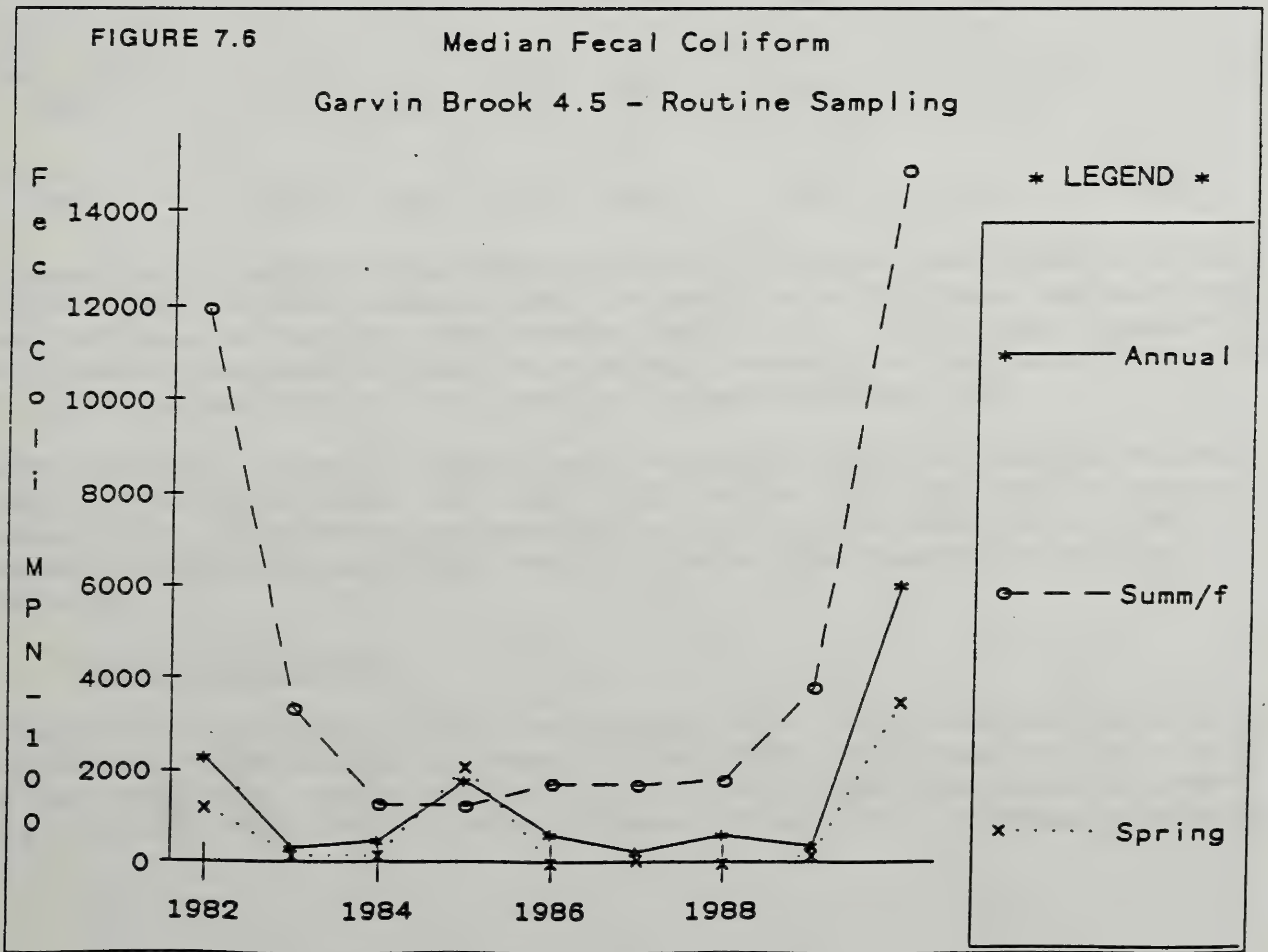


FIGURE 7.6
Median Fecal Coliform
Garvin Brook 4.5 - Routine Sampling
Fec Coli MPN-100
14000
12000
10000
8000
6000
4000
2000
0
1982
1984
1986
1988
* LEGEND *
Annual
Summ/f
Spring

Since median baseflow conditions were low both in 1982 and 1989-90, it was thought that the flow rates may help explain the water quality trends. However, when parameter concentrations were correlated with flow at the time of sampling, the only parameters with statistically significant correlation were nitrate and conductivity. Therefore, there is little evidence suggesting that the increases in sediment, phosphorus, and bacteria occurring from 1987 to 1990 was flow related. It appears that baseflow water quality has neither improved or degraded at station GB-4.5 between 1982 and 1990.

Storm Event Monitoring and Modeling

Three storm events with greater than 1.6 inches of rain were monitored at two sites on Garvin Brook (June 7-8, 1984; June 16-17, 1984; May 24, 1989). The average precipitation amounts over the watershed, peak flow rates, suspended sediment loading and phosphorus loading for the storm events are shown in Table 7.1.

Table 7.1. Average watershed precipitation, peak flow rates, suspended sediment loading, phosphorus loading, and AGNPS computer model predicted loadings for three storm events (for site GB-4.5; 4.5 miles from mouth of Garvin Brook).

Date of Storm	Average Rainfall (inches)	Peak Flow (CFS)	Storm E.I. Book Value	Predicted Sediment Loading (tons)	Measured Sediment Loading (tons)	Predicted Phosphorus Loading (lbs)	Measured Phosphorus Loading (lbs)
June 16-17, 1984	1.65	410	7	1070	806	--	--
June 7-8, 1984	2.2	700	14	2620	2855	--	--
May 24, 1989	1.65	450	7	980	700	4113	3000

A comparison of Agricultural Nonpoint Source Pollution Model (AGNPS) predicted sediment and nutrient transport near the mouth of Garvin Brook was made with measured results from the three storms (Table 7.1). Since storm intensity was not directly measured, typical storm energy intensity values based on the amount of precipitation received were used in the modeling exercise.

AGNPS predicted sediment loadings were reasonably close to measured sediment loading, varying by +28%, +33%, and -8.6% for the two 1.65" and 2.2" storms, respectively. Phosphorus was measured only during the 1989 storm. AGNPS phosphorus loading predictions were 32% greater than monitoring results indicated.

Brown Trout Surveys

Brown trout populations, which are very sensitive to climatic and hydrologic conditions, varied greatly between 1979 and 1990. Three year running average spring population, spring total weight, and fall fingerling abundance trends for two "control" sites are plotted on Figures 7.7 and 7.8. By visual examination,

FIGURE 7.7

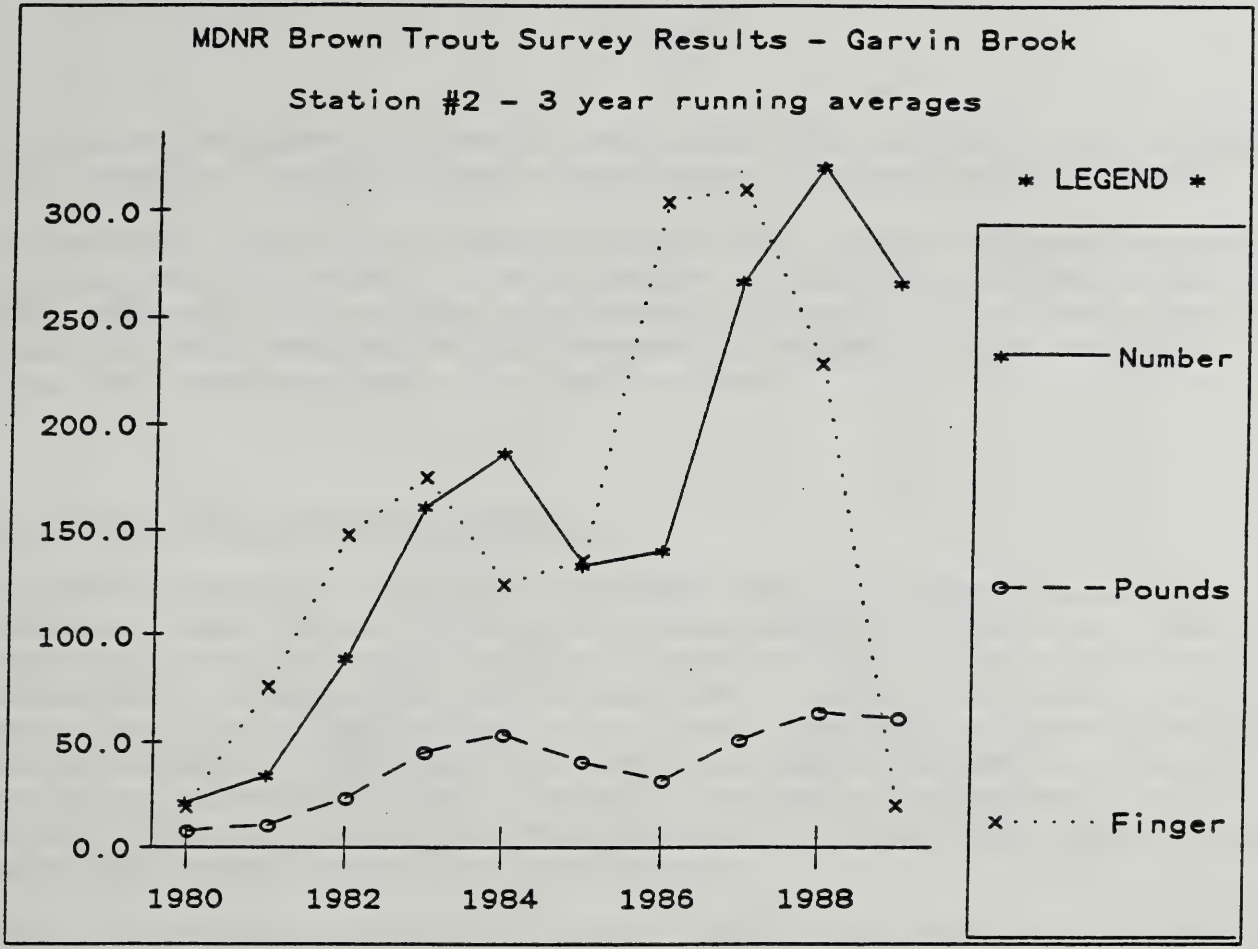
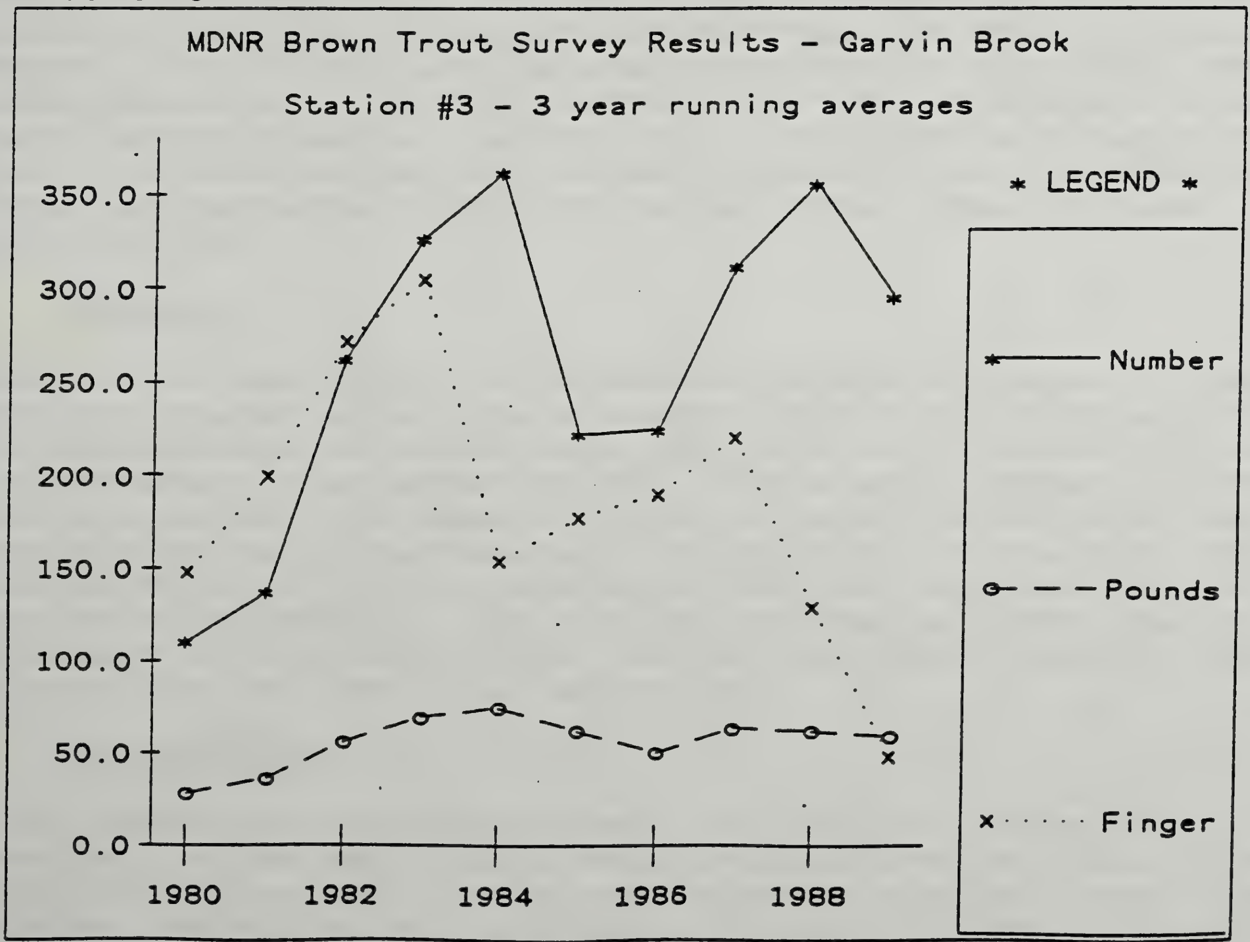


FIGURE 7.8



[illegible]

[illegible]

it appears that there has been an increasing trend in Brown trout population and total weight at station #2 and a less dramatic increase at station #3.

The number of brown trout generally follows the trend of fingerling abundance, but lags one year behind. A sharp decline in fingerling abundance was found for 1988, 1989 and 1990, perhaps in response to drought. It is likely that the trend for trout populations will decrease in response to the decreased fingerling abundance during the past few years.

7.4 Vadose Zone Monitoring Results

The karstic nature of the Prairie du Chien Formation makes tracking of pollutants from the land surface into the aquifer very difficult. Therefore, monitoring within the soil and glacial deposits was important to better define the polluting potential of various land uses in the project area. In this report, soil water sampling will refer to all sampling conducted above the bedrock aquifers. Where possible, monitoring was conducted in saturated conditions, which were found at several sites above low permeability till or bedrock. However, these sites were difficult to locate and a certain amount of monitoring in unsaturated soil took place.

Samples were first taken during February 1988 at selected sites. Sampling also took place during April, July and October 1988, and four times in April and May 1989. Because several soil-water samplers were installed in October 1988 and water was sometimes unattainable from certain lysimeters, not every site was sampled on the noted dates. Nitrate analyses were performed on all vadose zone samples and pesticide analyses were performed when over 300 ml of water was obtained. One liter of water was usually submitted for base neutral pesticide extraction analysis. Chloride, ammonium, sulfate and other major soil water constituents were sampled at selected sites. The following discussion will focus on nitrogen and pesticide analyses. Figures 7.9 and 7.10 show average nitrate and maximum pesticide concentrations at the various soil water monitoring sites.

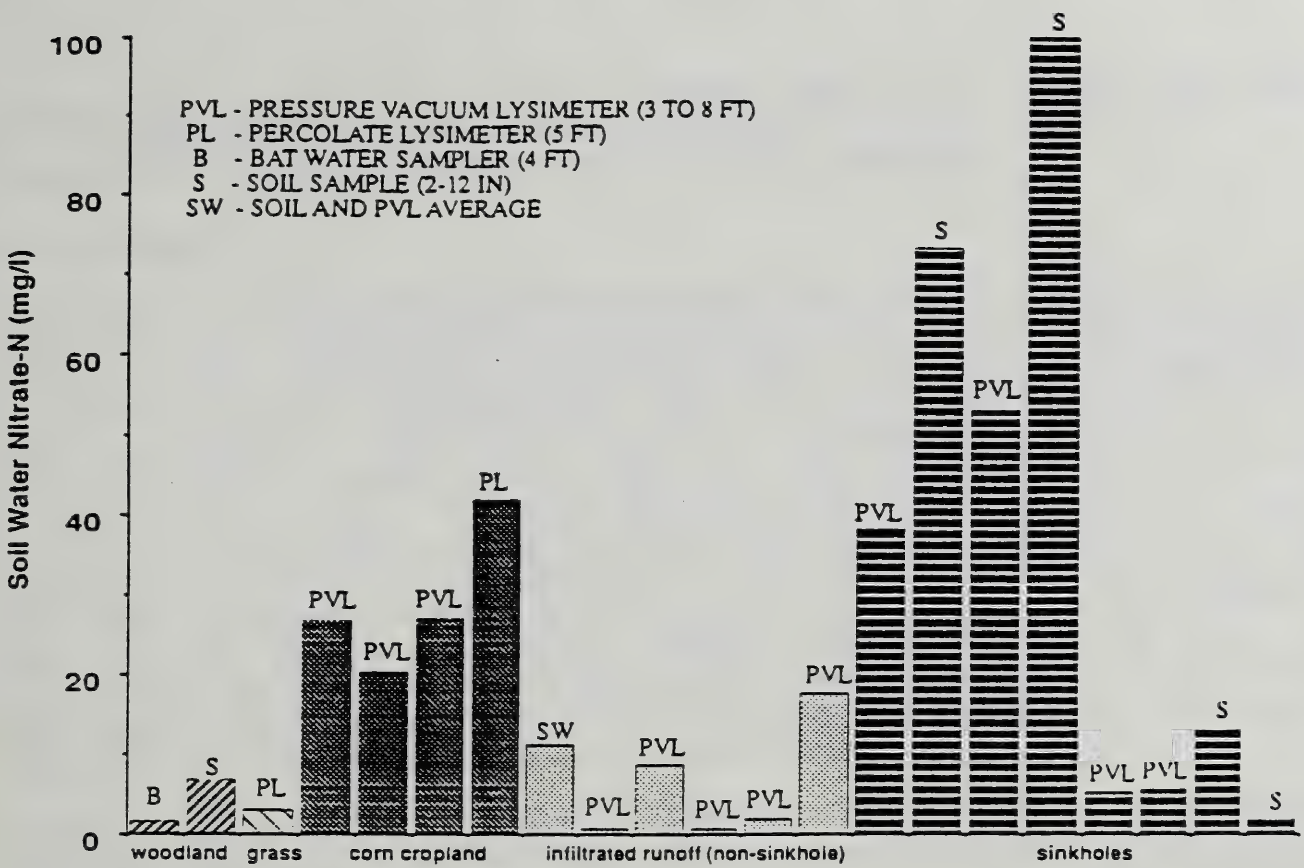
Grassland

Land that has been set aside in the Conservation Reserve Program (CRP) and planted to grasses was monitored as a control site--a site where no fertilizers or pesticides have been applied since 1985. Corn was the primary crop grown on the land before it was entered into CRP. Four percolate lysimeters, three glass block and one wick, were placed at a five-foot depth into silt loam loess soil. Nitrate concentrations were generally less than 1 mg/l at this site, with one analysis of 7 mg/l. Eighteen base neutral pesticides were analyzed in water from two of the lysimeters. The only pesticide that was detected was 0.02 ppb atrazine at one site in April 1989. This low concentration could be residual atrazine from 1983, when it was last applied.

Woodland/Pasture

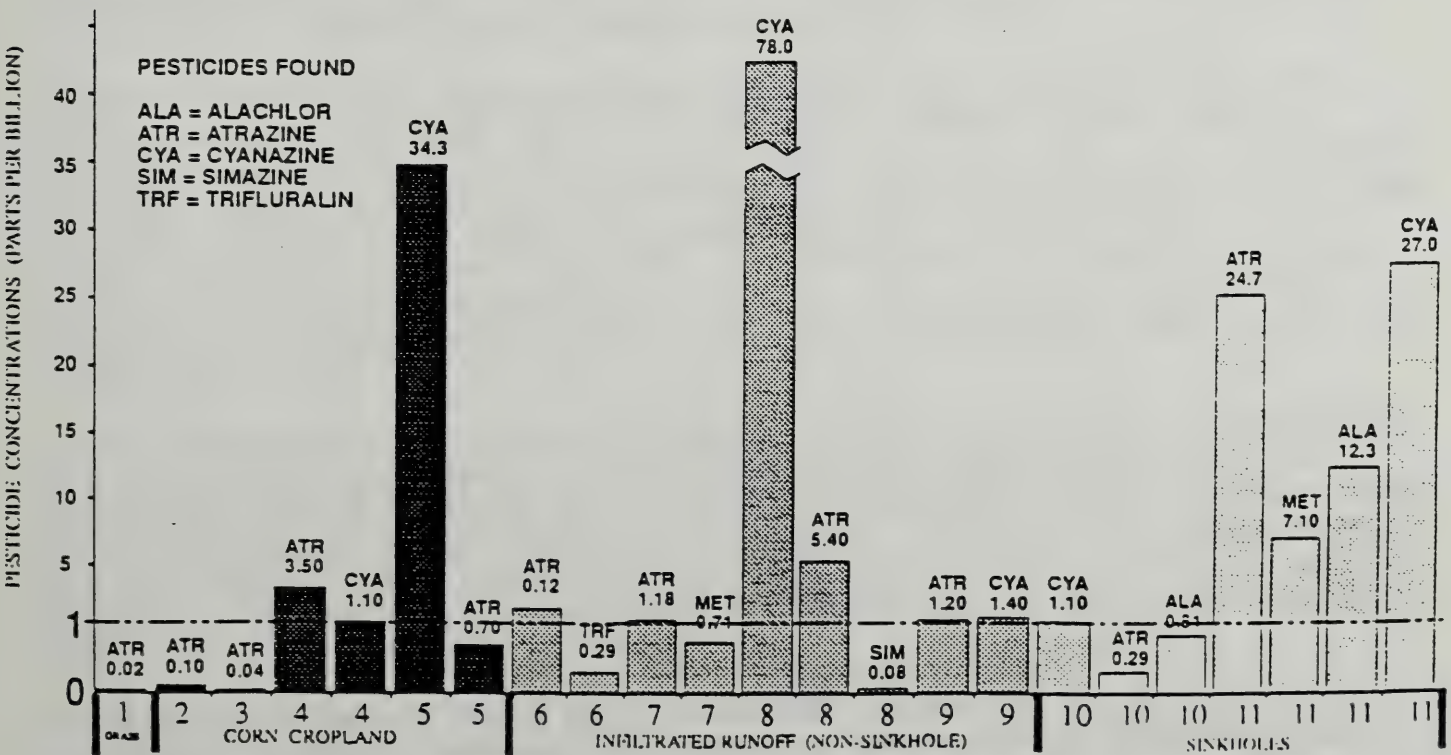
A BAT (essentially a high-tech lysimeter) was installed 4.5 feet into a saturated clay loam soil within a predominantly woodland and grassland area that is occasionally pastured. In five sampling events, nitrate-N concentrations were low, ranging from <0.5 to 4.7 mg/l. No base neutral extractable pesticides were found in three analyses at this site.

FIGURE 7.9
AVERAGE SOIL WATER NITRATE-N CONCENTRATIONS



Soil water nitrate-N concentrations under various land uses. Each bar represents the average nitrate-N concentration from all samples collected at a given site (1 to 4 lysimeters and 1 to 8 sampling dates).

FIGURE 7.10
MAXIMUM SOIL WATER PESTICIDE CONCENTRATIONS



Maximum pesticide concentrations found in lysimeters and BATs at depths between 3 and 8 feet. Each number, 1 to 11, represents a different field site (e.g. different farm). Sites 1, 2, and 3 had only one pesticide detected; whereas site 11 (a sinkhole south of Lewiston) had 4 different pesticides detected. Two sites in woodland/pasture were the only sites with no pesticide detections. Note the change in the Y-axis at 1 ppb.

Composite soil samples were taken in October 1988 at two woodland locations at a two- to six-inch depth under leaves from deciduous trees. Nitrate-N concentrations were 6.3 and 6.9 mg/l in the two samples.

Corn Cropland

Lysimeters were installed and regularly monitored in four fields that have been planted in corn. Corn field #1 has been planted in corn and contracted under RCWP since 1986 and alfalfa was grown previous to the corn. Nitrogen has been applied at a rate of 165 pounds/acre since 1986 and the primary herbicides used have been cyanazine, alachlor and atrazine. Six samples taken from a four-foot pressure vacuum lysimeter (PVL) at this site have had nitrate-N concentrations between 20 and 43 mg/l. Nitrate-N concentrations in an eight-foot PVL were usually slightly lower, ranging between 15 and 25 mg/l in seven samples. A BAT at a depth of 22 feet below loess, sandy clay loam, and sandy loam soils, had water with nitrate-N concentrations between 14 and 22 mg/l in three samples taken in 1988. From a total of nine samples taken at three depths (four, eight, and 22 feet) and analyzed for 18 base neutral pesticides, only two detections were found. Atrazine was found at 0.10 and 0.08 ppb on April 12, 1989, at the four and eight foot deep lysimeters, respectively.

Two PVLs were installed in corn field site #2 -- one was placed into unsaturated silty clay loam at a four foot depth and the other was placed in saturated soil at an eight-foot depth. The land was planted to soybeans in 1984 and has since been in corn with 100-125 pounds of commercial nitrogen fertilizer applied per acre each year. In addition, an unknown amount of liquid and some solid hog manure is applied on this land once annually. Nitrate-N concentrations have remained between 18 and 29 mg/l in the four-foot lysimeter and 23 to 37 mg/l in the eight-foot lysimeter. Atrazine was detected in water from both lysimeters in 1989 at concentrations up to 3.5 ppb. Cyanazine was also found at a concentration of 1.13 ppb in the four-foot lysimeter. Trifluralin was detected at 0.29 ppb in the eight-foot lysimeter on April 25, 1989.

In corn field site #3, three percolate lysimeters (one wick and three glass block) were installed five feet into a loess soil during October 1988 and sampled one to two times in April and May 1989. The land was contracted under RCWP and corn has been grown since before 1986, with 157 pounds/acre of nitrogen fertilizer applied since 1986. Atrazine, EPTC and cyanazine have been the primary herbicides applied since 1986. Nitrate-N concentrations in the four lysimeters have ranged between 34 and 48 mg/l. The herbicide atrazine was detected at a maximum concentration of 0.7 ppb and cyanazine concentrations were as high as 34.3 ppb.

In corn field site #4, a four-foot pressure vacuum lysimeter and a 19-foot BAT were installed on the edge of a field where hay was grown in 1986 and 1987 followed by corn in 1988 and 1989. Nitrate-N concentrations in the 19-foot deep BAT have generally ranged between 14 and 20 mg/l. Atrazine has been detected at very low levels -- <0.2 ppb in both the lysimeter and BAT. Trifluralin was also detected in the BAT at a concentration of 0.23 ppb during one of six sampling events.

The elevated nitrate-N (20-50 mg/l) under RCWP contracted fields suggests that either more stringent measures were needed to reduce nitrate leaching or more time was needed to observe the full benefits from the implemented nitrogen management BMPs.

Runoff Infiltration Areas (non-sinkholes)

Four non-sinkhole sites were monitored where runoff water ponds and infiltrates.

A PVL was placed 2.5 feet deep in a small erosion channel 10 feet from a field that is in continuous corn. During storms, large volumes of water flow through this channel, some of which infiltrates. Water running over this site, in addition to water running off from other corn acreage, alfalfa, clover, and pasture land is contained by an erosion control dam. Bedrock exists one to two feet below the ground surface at the dam and drainage from the pond into underlying bedrock occurs at a fairly rapid rate. A PVL was placed 1.5 feet into the sediment at the center of the pond. Nitrate-N concentrations in the 2.5 foot deep lysimeter in the erosion channel ranged between 6.9 and 10.2 mg/l. Pesticides were found during all (two) sampling events in April and May 1989. Atrazine concentrations were 5.4 and 4.8 ppb and cyanazine concentrations were 0.7 and 78.0 ppb in the April and May sampling events at this site, respectively. Nitrate-N concentrations below the pond were quite low (less than 4 mg/l). Atrazine and cyanazine were both detected below the pond at concentrations of 1.2 and 1.4 ppb, respectively.

At a different dam site, water ponds from pastureland, cropland, and feedlot runoff following storms and snowmelt. The pond was dry in the fall of 1988. A soil sample taken at a four- to six-inch depth in the bottom sediment had 46 mg/l of nitrate-N. The grab samples taken from the pond at this site in the spring of 1989, where over six feet of water was standing in the pond, all had total nitrogen concentrations less than five mg/l.

At the third runoff-infiltration site, a 23-foot deep monitoring well and a four-foot BAT on unsaturated soil are located in a swale that receives runoff from an adjacent corn field and grassland. The well is located in a thin layer of redeposited sandstone under eight feet of silty clay loam and 13 feet of sandy clay loam till. Five samples from the BAT have had an average nitrate-N concentration of 17.5 mg/l, and five samples form the monitoring well have had an average nitrate-N concentration of 7.3 mg/l. Water from the BAT was analyzed for pesticides in April and May 1989. In April, 0.12 ppb atrazine and 0.29 ppb tribluralin were found. No pesticides were detected in the May sample. In five pesticide analyses of monitoring well water, atrazine was found twice (0.05 and 0.07 ppb) and cyanazine was detected once (1.42 ppb).

The last ponded runoff site to be discussed in this section exists 50 feet from a highway in a low lying area that is flooded after snowmelt or rain. Runoff waters entering this site originate primarily from a commercial pesticide and fertilizer applicator company that is located across the road, with a culvert under the road providing a hydrologic connection to the site. Other water at this site originates from road ditch runoff and cultivated cropland. A PVL was installed at a four-foot depth in primarily colluvial silt loam sediment. Two nitrate-N concentrations measured in water from this lysimeter were less than 0.5 mg/l. Atrazine (0.085 and 1.18 ppb) and metolachlor (0.5 and 0.71 ppb) were found in both sampling events at this site.

Sinkholes

PVLs were installed in four sinkholes and soil samples were collected from several other sinkholes in the Garvin Brook Project Area. The quality of sinkhole soil water was quite variable depending on the land uses where runoff water into the sinkhole originated. For example, sinkholes which received runoff water from corn cropland generally had between 20 and 100 mg/l of nitrate-N in soil at the bottom of the sinkhole, whereas sinkholes surrounded by grassland and hay had between two 20 mg/l of nitrate-N. One small sinkhole in a fertilized pasture had nitrate-N concentrations between 25 and 50 mg/l.

Soil water from the bottom of five sinkholes was analyzed for pesticides. Two sinkholes had pesticide detections. One sinkhole received runoff from cropland and had nitrate-N concentrations of 17 to 34 mg/l in 1988 and 43 to 73 mg/l in 1989. While no pesticides were found from this sinkhole in 1988, three pesticides were detected in May 1989 (atrazine, 0.29 ppb; cyanazine, 1.1 ppb; and alachlor, 0.81 ppb). The sinkhole which appeared to pose the greatest concern for ground water quality was a sinkhole that received runoff primarily from the city of Lewiston. A series of five sinkholes located about 2000 feet south of Lewiston receive much of the runoff from Lewiston. A PVL was placed 2.5 feet into sediment which had eroded into the first sinkhole receiving runoff water. While nitrate-N concentrations were always measured between 2 and 9 mg/l, atrazine and metolachlor were consistently found at elevated concentrations and alachlor and cyanazine were also detected in two sampling events. The maximum and cyanazine were also detected in two sampling events. The maximum concentrations found in the sinkhole lysimeter were as follows: atrazine 24.7 ppb, metolachlor 7.1 ppb, alachlor 12.3 ppb, and cyanazine 27 ppb.

Follow-up monitoring of runoff water from the city of Lewiston and a comprehensive pesticide application facility inspection by the Minnesota Department of Agriculture at five commercial applicators in Lewiston showed that sloppy pesticide handling at three facilities resulted in very high pesticide residues in the soil at the facilities. Eight pesticides at concentrations over 1000 ppb were found in soil samples taken at the facilities. Alachlor, atrazine, cyanazine, metolachlor and EPTC were measured in soil samples to be over 70,000 ppb in at least one sample. The highest concentration of any pesticide in soil samples at the facilities was of EPTC at 1,555,000 ppb. On-site leaching of pesticides at these sites is likely a greater source of ground water contamination than runoff into the sinkholes.

7.5 Geologic Descriptions

Most of the geologic investigation was conducted for preparation of the Winona County Geologic Atlas in 1984. Within this section of the report, an overview of the surficial, bedrock and hydrogeology are provided based on the Winona County Geologic Atlas, Geology of Minnesota Centennial Volume, ongoing work by Minnesota Geological Survey and personal observations. The focus of this discussion is on the geology in the vicinity of the Ground Water Recharge Area.

Surficial Geology

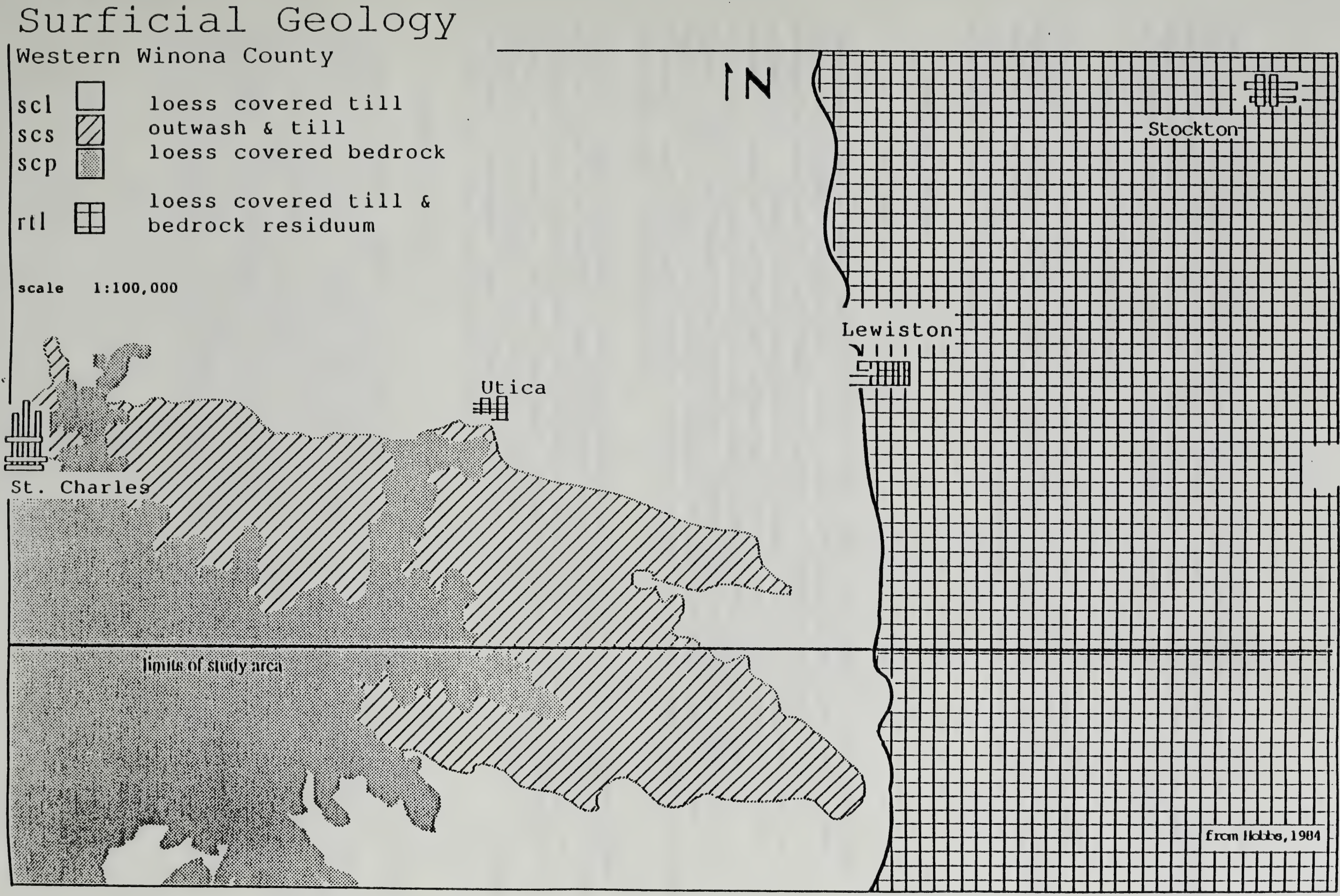
Pleistocene glacial deposits cover the study area. These unconsolidated sediments overlie the bedrock formations and comprise the surficial materials, except for a few small areas of alluvium and colluvium. Hobbs (1984) mapped three prevalent units in the study area: rtl loess-covered till and bedrock residuum; scs, outwash and till; and scl, loess-covered till, as shown in Figure 7.11.

Map Unit Descriptions

The map unit rtl (loess-covered till and bedrock residuum) covers most of Garvin Brook watershed. Hobbs (1984) dates rtl as Pleistocene, possibly Pre-Illinois. The typical glacial stratigraphy for this unit from bottom to top is: bedrock residuum, loess, till, and loess. The lower three layers appear to be absent in downcutting drainages, while the uppermost loess layer tends to drape into the drainages. The bedrock residuum is made up of sandy and clayey material formed by the weathering of the underlying bedrock formations. In the study area, the residuum is generally less than five feet thick and patchy. The till component of rtl ranges in texture from clay to clay loam and sandy clay to sandy clay loam. The pebble fraction of this till is dominated by weathered igneous rock fragments. Chert and sandstone fragments are found locally and carbonate fragments are absent. The till is usually less than ten feet thick and is thickest on the drainage divides and thin or absent near the drainages. The loess layers are composed of unbedded brownish silt loam. These layers were originally calcareous, but the carbonate material has been leached from the top five to eight feet. The loess layers are greater than ten feet thick on the drainage divides and thin or absent in the valleys. The map unit scl (loess-covered till) covers most of the Ground Water Recharge Area. It is bounded to south primarily by scs. The unit consists of a lower layer of till and an upper layer of loess. The till component is equivalent to the till in unit scs, and the loess component is similar to the loess component in unit scl. According to Hobbs (1984) the three units: scl, scs, and scp are of Pleistocene, possibly Pre-Illinoian age, and are stratigraphically higher than the unit rtl.

The map unit scs (outwash and till) makes up the southwestern corner of the Ground Water Recharge Area. The units consists of a single unit of thin gray calcareous till less than ten feet thick, with localized patches of outwash.

FIGURE 7.11



Surficial Geology Map

The till is typically loam to clay loam, and contains pebbles, cobbles, and boulders. The till is usually less than ten feet thick and brown and non-calcareous where exposed to the surface. Granitic fragments of the Canadian shield dominate the very coarse sand fraction. Sand and coarser size particles of limestone and dolostone can be found where the till has not been leached.

Thickness of Glacial Cover

Lithologic information from well logs suggest that the thickness of glacial material over the bedrock varies from three to forty feet. The glacial material does not systematically thicken in any one direction, rather the variation in thickness is probably attributable to the erosional irregularities in the underlying bedrock surfaces.

Bedrock Geology

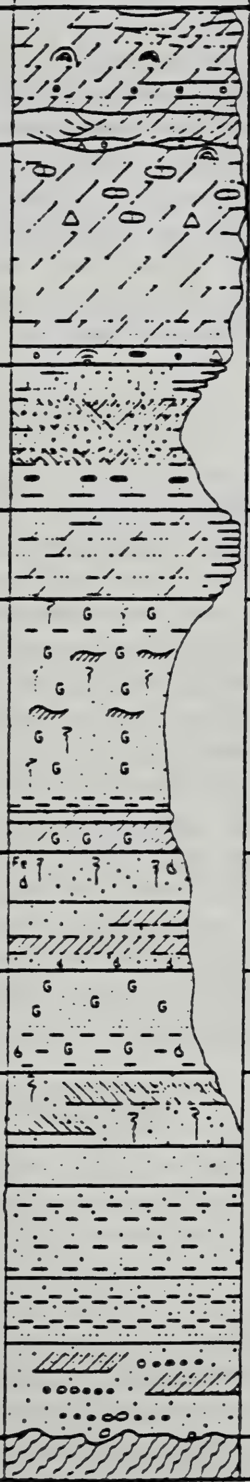
Overview

The stratigraphic units encountered in the study area range in age from Upper Cambrian to Middle Ordovician. During this time a shallow continental sea covered Winona County, and widespread layers of sand, clay and lime mud accumulated. These layers were eventually compacted and lithified into the presently observed sedimentary sequence. The sequency is summarized in a stratigraphic column constructed by Mossler and Brook (1984), shown in Figure 7.12. The formations approximate planar tabular bodies which have a regional dip of only one sixth of a degree to the west-southwest. These Paleozoic strata probably overlie Precambrian granitic gneisses which have been observed east of the study area.

Since the focus of ground water monitoring was on the Prairie du Chien-Jordan Aquifer, geologic descriptions will focus on this aquifer. The Jordan Sandstone represents the youngest Cambrian sediments in the study area. The Prairie du Chien Group caps the Jordan throughout the area, except in some drainages and valleys in the eastern part of the study area. The Jordan is a laterally continuous sandstone that varies in thickness from approximately 100 to 110 feet in the study area (Setterholm, 1991).

Jordan Sandstone

In Western Winona County the Jordan Sandstone can be divided into three members, namely the Van Oser Mb, the Waukon or Sunset Point Mb, and the Norwalk Mb (Setterholm, 1991). The Van Oser Member makes up most of the upper 90 to 100 feet of the Jordan. It is characteristically a medium-grained, white to yellow, quartzone sandstone, although grain size varies from coarse to fine sand (Webers, 1972). Very fine-grained, felspathic, dolomitic, well cemented beds of sandstone and interbedded siltstone are found within the Van Oser Member (Odom and Ostrom, 1978). Setterholm (1991) suggests that these strata are analogous to the Waukon Member of northeastern Iowa and southwestern Wisconsin and the Sunset Point Member of south central Wisconsin. These very fine-grained beds



SYSTEM SERIES	GROUP OR FORMATION NAME		SYMBOL	THICKNESS (feet)	DESCRIPTION
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	SHAKOPEE FORMATION	Ops	90 to 115	Thin-bedded and medium-bedded dolomite with thin sandstone and shale beds. Basal 20 to 30 feet is fine-grained quartzose sandstone. Local red iron staining. Basal contact minor erosional surface
LOWER ORDOVICIAN	PRAIRIE DU CHIEN GROUP	ONEOTA DOLOMITE	Opo	160 to 180	Thick-bedded to massive dolomite. Some sandy dolomite in basal 10 to 20 feet. Vugs filled with coarse calcite in upper part. Minor chert nodules. Upper part near contact with Shakopee commonly brecciated
UPPER CAMBRIAN	JORDAN SANDSTONE		Ꞓj	100 to 120	Sandstone. Top 30 feet is thin bedded and well cemented by calcite. Middle part is medium- to coarse-grained quartzose sandstone: generally uncemented and iron stained in outcrop. Basal 35 to 40 feet is very fine to fine-grained sandstone
UPPER CAMBRIAN	ST. LAWRENCE[1] FORMATION		Ꞓs	50 to 75	Thin-bedded dolomitic siltstone. Minor shale partings
UPPER CAMBRIAN	FRANCONIA[1] FORMATION		Ꞓf	140 to 180	Thin-bedded. dolomite-cemented glauconitic sandstone. Very fine to fine grained. Contains minor dolomite beds near base and shale partings throughout
UPPER CAMBRIAN	IRONTON & GALESVILLE SANDSTONES		Ꞓig	90 to 120	Ironton: Poorly sorted. silty. fine- to medium-grained quartzose sandstone with minor glauconite Galesville: Fine- to medium-grained. well-sorted quartzose sandstone
UPPER CAMBRIAN	EAU CLAIRE[2] FORMATION		Ꞓe	90 to 125	Very fine to fine-grained sandstone and siltstone. Some is glauconitic. Interbedded shale
UPPER CAMBRIAN	MT. SIMON[2] SANDSTONE		Ꞓm	290 to 350	Fine- to very coarse grained. poorly cemented sandstone. Contains pebbles in basal 20 to 40 feet. Sandstone generally moderately to well sorted. Greenish-gray shale mottled with grayish-red in basal third of formation. Basal contact major erosional surface
PRECAMBRIAN[3]			pꞒ		Biotitic granite gneiss in eastern part. Poorly known in west

FIGURE 7.12 Stratigraphic sequence of Paleozoic bedrock in the Garvin Brook RCWP Project Area (modified from Mossler and Book, 1984).

range in thickness from 2 to 30 feet and can be traced up to eight miles along generally 10 feet thick. It is typically described as a very fine-grained dolomitic feldspathic sandstone (Odom and Ostrom, 1978) which may contain layers of siltstone in the study area (Setterholm, 1991).

The Van Oser Mb is overlain by a unit of interbedded dolomitic sandstones, sandy dolostones, sandstones, and lesser amounts of siltstones, shales, and cherts. This heterogeneous unit has been called the Coon Valley Mb by Odom and Ostrom (1978). The unit's distinctive lithology is not characteristic of either the Jordan Sandstone or the Prairie due Chien Formation. For this reason, the Coon Valley Mb is considered by some as part of the Jordan Sandstone, while others include it as part of the Prairie du Chien Formation. Work performed by the Minnesota Geological Survey suggests that the Coon Valley Mb may be laterally continuous and is 25 to 30 feet thick in the western Winona County study area.

Prairie du Chien Group

The Prairie du Chien Group lies above the Coon Valley Mb. The Prairie du Chien has a maximum thickness of approximately 270 feet. However, since it is usually the uppermost bedrock in the study area, in many places some of its original thickness has been removed by erosion. All formations in the Prairie du Chien Group are laterally continuous in the study area. The Prairie du Chien Group is divided into the lower Oneota Dolomite and the upper Shakopee Formation (Davis, 1966). The Oneota Dolomite is thick-bedded, light brownish gray to buff, fine to medium-grained dolostone with a silt size dolomite matrix (Austin, 1972). It is approximately 120 feet thick in the study area. The Shakopee Formation is divided into the lower New Richmond Mb and an upper Willow River Mb. The New Richmond Mb is approximately 50 feet thick in the study area and consists of fine-grained quartzose sandstone and sandy dolostone with minor amounts of shale (Austin, 1972). The bottom 10 feet of the New Richmond Mb consists of interbedded dolostone, sand dolostone, and sandstone (Setterholm, 1991). The Willow River Mb is composed of thin to thick-bedded dolostone, sandy dolostone, sandstone and some grayish-green scale (Austin, 1972) and may exceed thicknesses of 100 feet in the study area (Setterholm, 1991).

Hydrogeologic Characteristics

The Prairie du Chien-Jordan aquifer may reach thicknesses of up to 400 feet in the study area. The upper part of the aquifer is the predominantly carbonate Prairie du Chien Group. The porosity of this unit is said to be post-depositional or secondary. After the Prairie du Chien Group was deposited, geologic stresses caused the unit to become fractured. This mechanical deformation was later enhanced by chemical dissolution. Ground water moving through the fracture networks dissolved the bounding limestone and dolostone creating cavities, and in some cases, caverns (Kanivetsky, 1984). The Jordan Sandstone makes up the bottom 100 feet of the aquifer. Much of the porosity of the Jordan Sandstone is primary and attributable to void spaces between the sand grains. Since these pore spaces are sufficiently interconnected, water is able to travel through the rock by moving through these pores (intergranular flow). It is possible, however, that the porosity of the Jordan was increased by fracturing resulting in both primary and secondary porosities, at least in some areas.

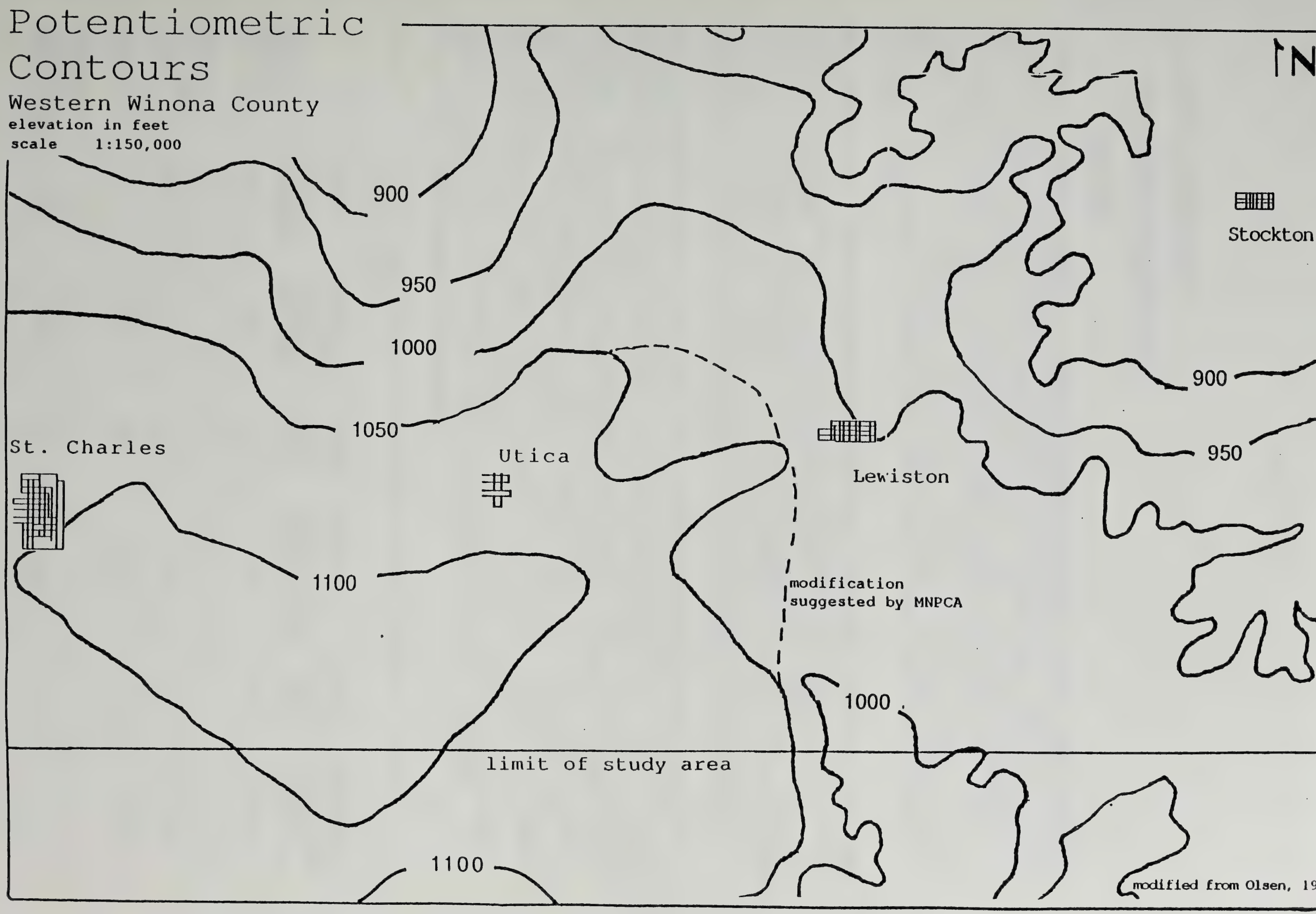
The Coon Valley Mb is a 30 feet thick unit which lies between the Prairie du Chien Group and the Jordan Sandstone. Most of the porosity in this unit is probably secondary, however, there is a possibility of intergranular flow, particularly in the more sandy and silty beds (Setterholm, 1991).

Potentiometric Levels

Kanivetsky (1984) constructed a hydrostatic pressure or potentiometric map for the Prairie du Chien-Jordan Aquifer in Winona County. Based on the results from this map boundaries were drawn for the Ground Water Recharge Area which was added to the RCWP project area. In addition, the MPCA collected static water elevations at 16 wells during November 1990 in order to see if major changes were evident since 1984 and to obtain measurements at locations that were previously not measured. For the most part, the static water elevations collected by the MPCA were within a few feet of those illustrated by the map of Kanivetsky (1984). The supplemental points aided in creating a modified version of Kanivetsky's 1984 map (Figure 7.13). The solid lines in Figure 7.13 represent points of equal hydraulic potential within the Prairie du Chien-Jordan Aquifer. In general, water flows towards the northeast near Utica and Lewiston, in the general direction of Garvin Brook.

In the ground water Recharge Area, the Prairie du Chien Group is the uppermost bedrock. Since the glacial material does not appear to be an effective confining layer, the Prairie du Chien-Jordan Aquifer is unconfined or under water table conditions in the project area. Static water levels in the Prairie du Chien-Jordan Aquifer decrease substantially with increasing distance from confined conditions west of the ground water recharge area. East of Lewiston the Prairie du Chien Group is so greatly dewatered that most wells must penetrate into the Jordan Sandstone to obtain sufficient yields. Static water level information seems to indicate that the Prairie du Chien Group and Jordan Sandstone are hydrologically connected and should be treated as one aquifer within the study area.

FIGURE 7.13



Potentiometric Map of Prairie Du Chien-Jordan Aquifer

7.6 Ground Water Results

Nitrate Monitoring Results

Overview

Of 80 wells sampled annually in Garvin Brook Watershed (between 1983 and 1990), the median nitrate-N concentration each year was generally between 4 and 5 mg/l, and in most years 20 to 24 percent of the wells exceeded the 10 mg/l drinking water standard for nitrate-N. An additional 81 wells were sampled annually in the adjacent Ground Water Recharge Area (GWRA) between 1985 and 1990. The median nitrate-N concentration of wells in the GWRA has been between 10 and 12 mg/l with 50 to 54 percent of all wells having nitrate-N greater than 10 mg/l. Only about 10 percent of wells in the GWRA have had nitrate-N concentrations less than 3 mg/l.

The lower nitrate concentrations in Garvin Brook Watershed compared to the GWRA could be due, in part, to less infiltration resulting from the steeper terrain and less cultivated land in Garvin Brook Watershed. Also, there is less sinkhole development in Garvin Brook Watershed compared to the GWRA, with the exception of a ridge top on the western and southwestern portion of Garvin Brook Watershed. However, the primary reason for generally lower nitrate in Garvin Brook Watershed relates to the aquifers from which the water is withdrawn.

Wells in the GWRA largely draw from the unconfined karstic Prairie du Chien Formation, whereas many more wells in Garvin Brook Watershed draw from the much less contaminated Jordan Sandstone, Franconia-Ironton-Galesvale, and Mt. Simon aquifers. The median nitrate concentrations shown in Table 7.2 for Prairie du Chien and Prairie du Chien-Jordan wells are much higher than for Jordan wells and Franconia-Ironton-Galesville wells. There are 66 wells for which casing depth and producing aquifer is known and nitrate data are available. The nitrate drinking water standard was exceeded in 59 percent (9 out of 16 wells) of Prairie du Chien wells, 50 percent (11 out of 22 wells) of Prairie du Chien-Jordan wells, 11 percent (two out of 17 wells) of Jordan wells and zero percent (zero out of 11 wells) of wells developed in the Mt. Simon and Franconia-Ironton-Galesville aquifers.

Table 7.2 Aquifer and well construction as related to median nitrate concentration

Aquifer	Total Number of Wells	Med NO_3-N (mg/l) for Tot Wells	Number Cased Wells	Med NO_3-N mg/l) for Cased Wells	Number Uncased Wells	Median NO_3-N for Uncased Wells
Prairie du Chien	16	10.8	4	9.5	12	10.8
Prairie du Chien-Jordan	22	12.5	5	6.75	17	14.0
Jordan	17	2.2	16	2.2	1	5.8
Franconia-Ironton-Galesville	11	0.01	11	0.01	0	--

There has been only one monitored well stratigraphically below the Jordan Formation that has been affected by nitrate. This well, reported in the well log to be developed in the Franconia Formation, is one of three municipal wells for the city of Lewiston. Nitrate-N concentrations in this well have gradually been increasing since 1970 from 3 mg/l to over 8 mg/l.

Table 7.2 also shows median nitrate concentrations for cased and uncased wells in the various aquifers. The presence and condition of casing appears to have an influence on well water quality in Prairie du Chien-Jordan wells. Median nitrate concentrations were more than twice as high in uncased Prairie du Chien-Jordan wells than in cased wells within the same aquifers.

Nitrate concentration and temporal variability in concentration was not found to be influenced by proximity of sinkholes.

Changes in Nitrate Concentration with Time

Time trend analysis was conducted on data produced from annual nitrate sampling[1] of numerous wells in Garvin Brook Watershed and the Ground Water Recharge Area. Wells chosen for trend analysis had 1) average nitrate-N levels during the first three years of testing that exceeded 3 mg/l, and 2) been sampled for a minimum of five continuous years. Wells with low nitrate ($<$ 3 mg/l) during the first three years of sampling were not analyzed for trends, since 1) the reporting limit during 1983 and 1984 was 3 mg/l, and 2) low nitrate water was shown to often represent water that had entered the ground over 35 years ago or a mix of older and more recent water.

Fifty-one wells in Garvin Brook Watershed met the selection criteria, 88 percent of which had been sampled each year between 1983 and 1990. The remaining 12 percent were sampled from 1985 to 1990. Sixty wells in the Ground Water Recharge Area met the data selection criteria, 83 percent of which were sampled each year from 1985 to 1990. Nine wells (15%) were sampled from 1986 to 1990 and one well was sampled from 1983 to 1990. Well sampling occurred each year between late-May and early July and took about two weeks to complete.

Kendalls tau test, which is a nonparametric test of correlation, was used to measure the direction and statistical significance of observed trends. Statistical analysis results are shown in Table 7.3 and Figure 7.14. Two measures of statistical significance are noted in Table 7.3, $p < 0.05$ and $p < 0.10$. Significance levels of $p < 0.05$ or $p < 0.10$ indicate that there is less than a 5% or 10% probability, respectively, of obtaining a slope as different from zero as the observed slope if in fact there is no relationship between parameter value and time. Significance levels of $p < 0.05$ and $p < 0.10$ are commonly used in scientific work to allow reasonable certainty that a relationship between parameter and time really exists.

Trend results for Garvin Brook Watershed and the Ground Water Recharge Area were similar. In both areas, trend analysis results differed greatly when comparing wells that had nitrate-N between 3 and 10 mg/l and those with greater than

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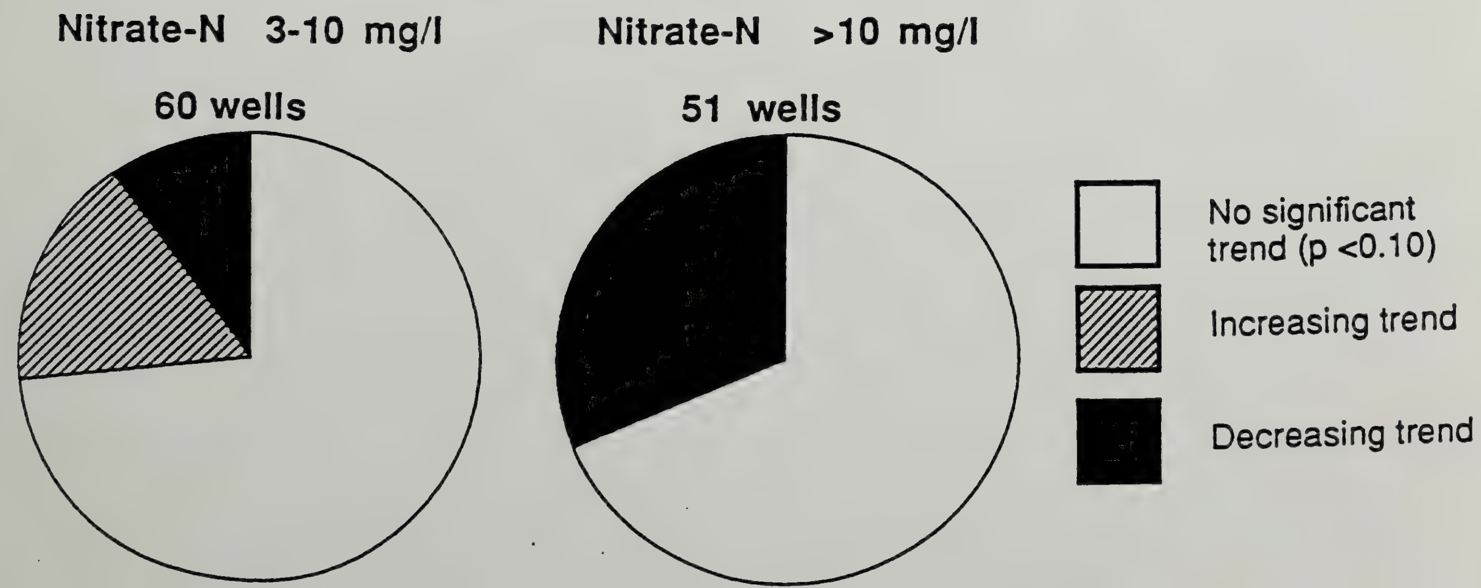
[1] Sampling was conducted by Winona County Extension and laboratory analysis was performed at the Minnesota Department of Agriculture Laboratory.

Table 7.3 Results of Kendalls tau test of correlation between nitrate and time conducted on data obtained from annual sampling in Garvin Brook Watershed and the Ground Water Recharge Area between 1983 and 1990.

Area	Nitrate Range	# of Wells	Statistic	# No Trend	# Increasing	# Decreasing
Garvin Brook Watershed	3-10 mg/l	35	$p < 0.05$	27(77%)	4(11.5%)	4(11.5%)
"	"	"	$p < 0.10$	24(69%)	6(17%)	5(14%)
"	"	"	*Slope dir.	--	21(60%)	14(40%)
Ground Water Recharge Area	3-10 mg/l	25	$p < 0.05$	22(88%)	3(12%)	0(0%)
"	"	"	$p < 0.10$	20(80%)	4(16%)	1(4%)
"	"	"	*Slope dir.	--	14(56%)	11(44%)
Garvin Brook Watershed	> 10 mg/l	16	$p < 0.05$	10(62.5%)	0(0%)	6(37.5%)
"	"	"	$p < 0.10$	8(50%)	0(0%)	8(50%)
"	"	"	*Slope dir.	--	4(25%)	12(75%)
Ground Water Recharge Area	> 10 mg/l	35	$p \leq 0.05$	30(86%)	0(0%)	5(14%)
"	"	"	$p \leq 0.10$	27(77%)	0(0%)	8(23%)
"	"	"	*Slope dir.	--	9(26%)	26(74%)

*Slope direction information includes many wells for which the slope is <u>not</u> statistically different from zero.

Figure 7.14 Nitrate concentration trends from wells sampled annually in Garvin Brook Watershed and the Ground Water Recharge Area for a period of 5 to 8 years (between 1983 and 1990). Kendalls tau test of correlation was used to determine the significance and direction of trends for the two categories of wells.



10 mg/l during the first few years of testing. Seventy-three percent of wells with nitrate-N between 3 and 10 mg/l had no significant trend ($p < 0.10$), and more wells in this range showed significant increasing trends (10) than decreasing trends (6). **However, when considering only wells that had over 10 mg/l during the first three years of sampling, the only statistically significant ($p < 0.10$) trends were decreasing trends.** Sixty-nine percent of 51 high nitrate wells had no significant trend and 31% had a decreasing trend.

It is unknown whether the observed decreases in the high nitrate wells are related to BMPs, climatic conditions or a combination of the two. It is possible that during the dry period between 1987 and 1989, nitrate concentrations decreased due to decreased leaching into the aquifer and denitrification and/or mixing of lower and higher nitrate waters within the aquifer. Continued monitoring of these wells should help to determine whether the trends are more likely due to climatic variability or implemented BMPs.

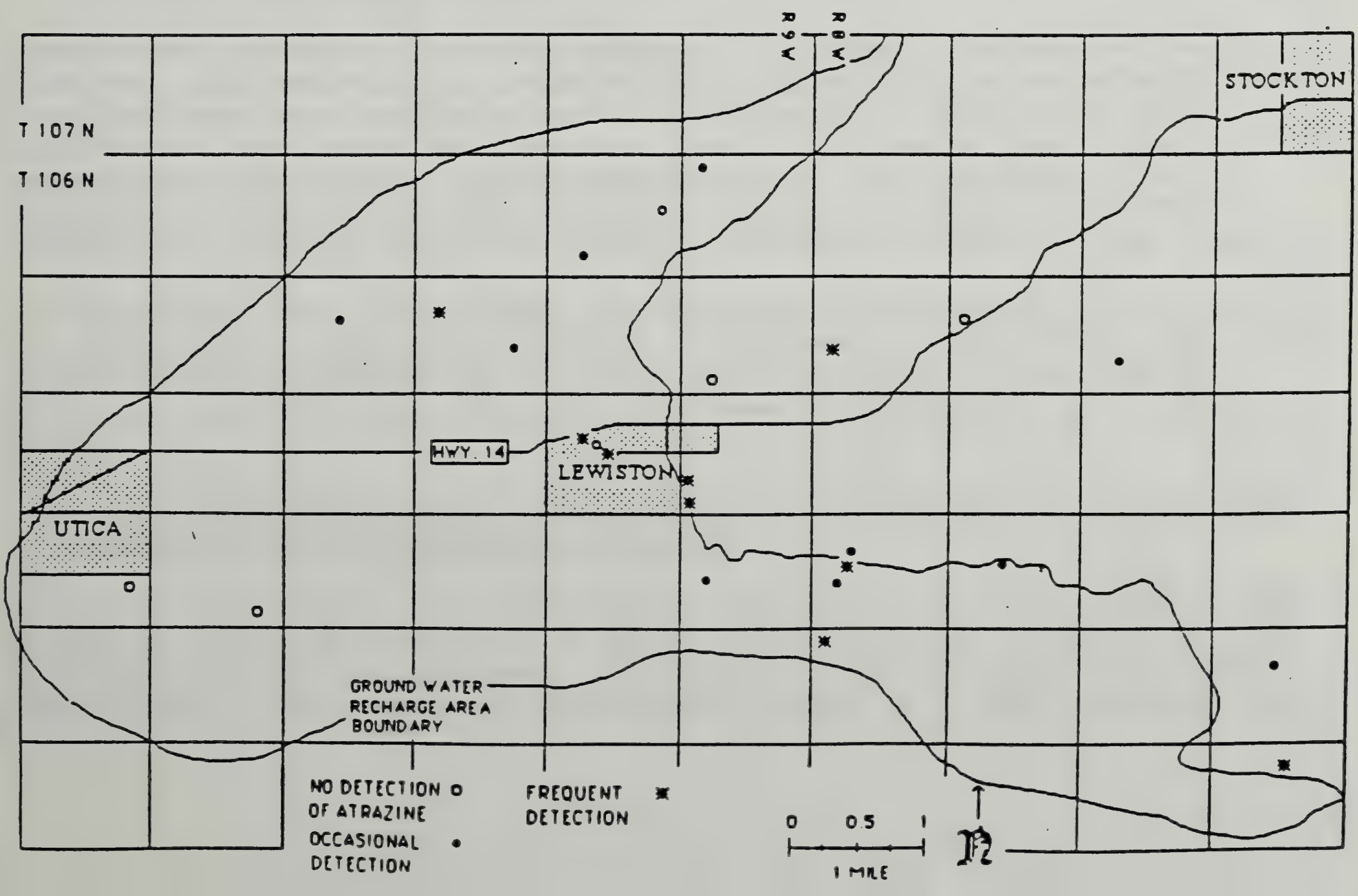
The major differences in trends between mid-range and high-nitrate wells could be related to ground water residence times. High nitrate wells are very sensitive to surface contamination and likely have quick residence times (very young water). Therefore, these wells may reflect more recent land use changes and climatic conditions. Wells with nitrate in the 3 to 10 mg/l range could be somewhat less sensitive to surface contamination and may not be as responsive to recent land use and climatic conditions as the high nitrate wells.

Pesticide Monitoring Results

Twenty-five wells, mostly within the Ground Water Recharge Area (GWRA), were sampled regularly for pesticides during 1988 and 1989 by three state agencies. The base neutral extraction process was used to determine concentrations of 18 different pesticides, which included many, but not all, of the most commonly used pesticides in Minnesota. Seventy-six percent of these wells had at least one detection of pesticides, primarily atrazine (Figure 7.15). Two wells (eight percent) have had frequent detections of atrazine above the recommended allowable limit for drinking water of 3 ppb.

Four of 10 wells with at least two atrazine detections occur in or adjacent to the city of Lewiston. Two of these four wells are Lewiston municipal wells. A municipal well in the Jordan Sandstone that is cased to a 326 foot depth has had two detections of atrazine (0.05 and 0.09 ppb). A Franconia Formation municipal well cased to 393 feet has had frequent atrazine detections at concentrations between 0.3 and 0.8 ppb. Both municipal wells also have elevated nitrate (6 to 9 mg/l). It is possible that large volume pumping of the municipal wells have drawn contaminated water from the Prairie du Chien downward, thereby affecting the lower aquifers. Leaks in the casing may also be a problem. The other two wells in Lewiston that have had pesticides are on the eastern edge of town and draw water from the Prairie du Chien-Jordan. Both wells consistently (eight analyses) had atrazine concentrations between 3 and 7 ppb. One of these wells also had five detections of dicamba (0.4 to 0.9 ppb) and three alachlor detections (0.15 to 0.5 ppb). The other well had one detection of alachlor (0.23 ppb) and one detection of metribuzin (0.18 ppb).

Figure 7.15 Relative frequency of atrazine detection in wells sampled for pesticides.



With the exception of the two wells on the eastern edge of Lewiston, atrazine has been the only pesticide detected in well water in the project area since 1987. Alachlor was found in two additional wells in 1985, but since has not been detected in those same wells.

Of the 13 Prairie du Chien and Prairie du Chien-Jordan wells regularly tested for pesticides, 12 had at least one detection. Six wells had infrequent low detections of atrazine (generally less than 0.2 ppb), and the other six wells had frequent atrazine detections, most at concentrations greater than 0.8 ppb.

Ten wells sampled for pesticides draw from the Jordan Sandstone: three had no detection, five had infrequent low-level detections (<0.1 ppb), and two wells had more frequent detections at concentrations greater than 0.1 ppb.

Two wells developed in the Franconia-Ironton-Galesville Formations were tested for base neutral pesticides. One well, the Lewiston municipal well previously discussed, had frequent atrazine detections and the other well had no detections.

The number of atrazine detections per sampling event decreased considerably in the very dry summer and fall months of 1988. The percentage of wells with detected atrazine increased in spring 1989. There has been no consistent seasonal pattern for when pesticides were detected more or less frequently, except for a few more detections in the spring months and a few less in summer.

Between 1986 and 1989 there was no obvious increasing or decreasing trends in atrazine concentrations. There have been a few slight increases or decreases over time, but generally the levels have remained constant.

Bacteria Monitoring Results

Twenty-three percent of the wells sampled in the study are showed at least occasional coliform bacteria contamination. Unlike nitrate contamination, the bacteria-contaminated wells are equally distributed between Garvin Brook Watershed and the Ground Water Recharge Area. Of 25 wells found to be contaminated with bacteria in one sampling event, five (20 percent) had nitrate-N analyses of less than 3.0 mg/l, nine (36 percent) had nitrate-N between 3 and 10 mg/l, and 11 (44 percent) had nitrate-N greater than 10 mg/l.

The Prairie du Chien, Mount Simon, and Franconia-Ironton-Galesville aquifers all had approximately equal percentages of coliform contaminated wells. The Jordan aquifer was less contaminated, with only one of 11 wells contaminated by bacteria. Cased wells were slightly less impacted by bacteria than uncased wells.

1989-1991 Study of Water Quality and Sensitivity of the Prairie du Chien-Jordan Aquifer in Western Winona County

A study was conducted in the Garvin Brook Area as part of a multi-agency study related to assessing sensitivity of ground water resources in Minnesota. The Minnesota Pollution Control Agency (MPCA) Water Quality Division focused on water quality of the Prairie du Chien-Jordan aquifer in a 100 square mile area

of west-central Winona County which included the Ground Water Recharge Area for the Garvin Brook RCWP. This summary discusses the results from two rounds of samples taken from 22 Prairie du Chien (PDC) wells and 32 Jordan Formation wells during the spring and summer of 1990. Primary goals of the study were to determine the variability of water chemistry within the formations, relate the water quality and variability to geologic sensitivity, and assess the factors affecting water quality and residence times within the aquifer. Nearly 90 percent of sampled wells had an associated well log and were completed in the PDC or Jordan Formation. Water from all wells was analyzed for nitrate and field parameters, and most wells were analyzed for other major ions, dissolved organic carbon and silica. Tritium (age dating) analysis was conducted on water from 22 wells and pesticides were analyzed in six wells. Geologic information was obtained largely from the Winona County Geologic Atlas, supplemented with downhole geophysical logging analyses performed by the Minnesota Geological Survey.

The Minnesota Department of Natural Resources ranked the geologic sensitivity throughout most of the project area as high or very high based on soil parent materials (level 1 assessment). Elevated nitrate, tritium and chloride concentrations in many wells throughout the project area suggest that portions of the Prairie due Chien-Jordan aquifer are indeed sensitive to surface contamination. However, great variability in nitrate, tritium, and other parameter concentrations was found throughout the project area.

In general, the water chemistries varied much less among Jordan wells as compared to water chemistry differences among PDC wells. While several PDC wells have water chemistries and quality similar to Jordan wells, PDC wells had high nitrate, chloride, sodium, calcium, and bicarbonate and lower pH than Jordan wells, on the average.

The maximum detected chloride and sulfate concentrations in both formations were far below secondary drinking water standards. Nearly 50 percent of the 22 Prairie du Chien wells sampled had nitrate-N in excess of 10 mg/l. Older PDC wells and PDC wells not protected by overlying shale tended to be more greatly impacted by nitrate and other dissolved solids. Nearly 75 percent of Jordan wells had nitrate-N in the range of one to seven mg/l. The highest nitrate-N concentrations found in Jordan wells were 10 mg/l in a municipal well and 11 mg/l in a domestic well. The water chemistry of the 1945 constructed municipal well indicated that the well was likely drawing much of its water from the PDC rather than the Jordan, due perhaps to a poor seal and high capacity pumpage.

Tritium analysis results showed that while some Jordan wells withdrew water which had more recently entered the aquifer, other Jordan wells were withdrawing water that had entered the ground prior to the mid 1950's. Of five PDC wells analyzed for tritium, three had recent water (post-1954) and two wells had a mix of older and recent water. The two mixed age PDC wells had nitrate-N concentrations averaging 2.4 and 0.36 mg/l. Of sixteen Jordan wells with tritium data, six wells have older water (pre-1954), six wells have recent water (post-1954) and four wells have mixed water. Four of the older water wells had nitrate-N concentrations less than 0.01 mg/l, and the other two older water wells had nitrate-N averaging 3.2 and 1.2 mg/l. The low nitrate concentrations in the pre-1954 water suggest that either very little nitrate was entering ground water before the mid-1950's or that nitrate entering ground water was

lost through denitrification, or a combination of the two. The potential for denitrification, based on redox potential, dissolved organic carbon and dissolved oxygen measurements, was high in the four nitrate-free wells and somewhat lower for the older water wells with measurable nitrate. A third round of sampling conducted in April 1991 will provide additional information to aid in further understanding residence times, nitrate levels and denitrification potential in the study area. The third round of data will be incorporated into a 1992 report to EPA.

Geophysical logging information, combined with well drillers log information and water chemistry results, show that higher nitrate concentrations and younger water is found in the PDC formation and upper Jordan formation. Since the Jordan Formation is divided into several geozones by lower permeability units, significant differences in water chemistry exist vertically within the Jordan. The lower part of the Jordan, especially where the Sunset Point Mb is present, is much less sensitive to surficial contamination compared to the PDC and upper Jordan. It is recommended that new wells in the area be cased at least 30 to 35 feet into the Jordan, where possible.

Vertical and lateral variability in water quality and residence times can be best understood when detailed geologic information is available. Relying on well driller's logs alone is insufficient for accurately defining geologic sensitivity in this region. The Minnesota Geological Survey produced a sensitivity map based on a number of geologic factors. Nitrate concentrations from this study corresponded fairly well with the sensitivity rankings. A minimum of a level 2 assessment (MDNR guidelines) should be used to evaluate sensitivity in similar areas of southeastern Minnesota. Geologic sensitivity assessments utilizing detailed geologic information appear to be a reasonable means of prioritizing where to implement Best Management Practice efforts (e.g. nitrogen fertilizer and pesticide management).

Due to the likelihood of denitrification in the deeper part of the Jordan Formation, and the relatively low residence times of water in the PDC and much of the upper Jordan, the nitrate situation could significantly improve in the PDC-Jordan aquifer within one generation following reductions in nitrate loading into the aquifer.

7.7 Relationships Between Land Use/Land Treatment and Water Quality

Using AGNPS Model to Predict Storm Event Nutrient and Sediment Delivery Changes Between Pre- and Post- BMP Implementation

The computer model AGNPS, Agricultural Nonpoint Source Pollution Model, (Young et al., 1987) was used to predict nutrient and sediment delivery to Garvin Brook during storm events. Because AGNPS modeling results were relatively close to stream monitoring results, it was decided that AGNPS modeling using pre- and post-BMP implementation land uses should provide a rough estimate of the affect of the RCWP on storm event sediment and nutrient delivery.

Watershed and land management information was originally input in 1984. This data set did not account for most BMPs introduced as a result of the Garvin Brook RCWP. In 1989, changes were made to eight AGNPS input parameters in 179

forty acre cells (22.6 percent of all cells in the watershed) based on actual RCWP contracted land use changes. In many of the 40 acre cells, BMPs were implemented on a certain fraction of the entire cell due to farm boundaries, forested land, or other land uses that could not be contracted under RCWP. The magnitude of changes made to the input parameters of each cell was based on the percentage of each cell that had BMP implementation.

Some contracts for BMPs expired in 1987 and 1988 but were still included in the data file parameter changes, along with new (1989) contracted BMPs. Therefore, the modeling was conducted under the assumption that all BMPs contracted during any year of the program were under implementation at the same time.

The original file was largely created by Winona County SCS staff. This file was modified by the MPCA in March 1989, to include the RCWP management practice changes that have taken place since 1982. The following is a list of the seven data file input parameters of the AGNPS model that were changed.

1. SCS Curve Number: Changes were made in cells that had conservation tillage systems and permanent vegetative cover implemented.

2. Mannings Roughness Coefficient: Changes were made in cells that had conservation tillage systems, permanent vegetative cover, sediment retention, erosion, or water control structures, and waterway systems.

3. Support Practice Factor: Changes were made where contour farming was implemented.

4. Fertilization Level: Reductions were made in cells that had fertilization management and were considered by Winona County SCS office to be operated by conservation minded individuals.

5. Fertilizer Availability Factor: Changes were made to cells that had conservation tillage implemented. However, changes were fairly minor due to the practice of injecting fertilizer in contracted areas.

6. Chemical Oxygen Demand: Parameter values were changed only if cropland was changed to pasture, forest, or permanent vegetative cover.

7. Point Source Designator: Where animal waste management systems were installed or where feedlots were determined to have a minimal impact on water quality, those cells were considered to have only one animal in the feedlot. One animal in the input file suggests that there is very little runoff from the feedlot area going into the stream.

8. Cover and Management (C-factor): The C-factor was found to greatly influence predicted sediment transport. Changes were made in cells with conservation tillage implemented or permanent vegetation established. C-factor values were representative of late May to early JUne conditions for Winona County.

The land use changes in the 31,640 acre watershed that were incorporated into model inputs were:

Conservation Tillage 3,364 acres
Fertilizer Management 4,739 acres
Contour Strips 1,471 acres
Permanent Vegetative Cover 611 acres
Waterway System 482 feet
Animal Waste Management Systems 15

The computer model was run for storms of varying degrees using both the original data set and the post-BMP modified data set. Tables 7.4 and 7.5 list pollutant delivery to the mouth of Garvin Brook for a one year 24-hour storm and a five year 24-hour storm during the period of late spring to early summer.

Slight differences in the percentage of improvement between pre- and post-BMP implementation were shown in several parameters. Predicted total sediment yield was 17 percent lower following implementation of the RCWP BMPs for the one- and five-year storms. The degree of predicted nutrient reduction was similar to that of sediment reduction, but varied with each nutrient parameter and storm size.

Table 7.4 Pre- and Post-BMP AGNPS modeled nutrient and sediment yield from a one year 24 hour storm (2.5 inches) with a Storm Energy Intensity value of 16.

	Pre-BMP	Post-BMP	%Improvement
Total nitrogen in sediment (lbs/acre):	0.56	0.49	13%
Total soluble nitrogen in runoff (lbs/acre):	0.31	0.28	10%
Soluble nitrogen concentration in runoff (ppm):	2.6	2.4	8%
Total phosphorus in sediment (lbs/acre):	0.28	0.24	15%
Total soluble phosphorus in runoff (lbs/acre):	0.06	0.05	18%
Soluble phosphorus concentration in runoff (ppm):	0.50	0.40	22%
Total soluble chemical oxygen demand (lbs/acre):	12.36	11.61	6%
Soluble chemical oxygen demand concentration in runoff (ppm):	102	100	2%
Total sediment yield (tons):	3623	3067	17%
Runoff (inches):	0.53	0.51	4%

Table 7.5 Pre- and Post-BMP AGNPS modeled nutrient and sediment yield from a five year storm (3.7 inches) with a Storm Energy Intensity value of 39.

	Pre-BMP	Post-BMP	%Improvement
Total nitrogen in sediment (lbs/acre):	1.48	1.29	14%
Total soluble nitrogen in runoff (lbs/acre):	0.57	0.52	9%
Soluble nitrogen concentration in runoff (ppm):	2.0	1.9	5%
Total phosphorus in sediment (lbs/acre):	0.74	0.65	13%
Total soluble phosphorus in runoff (lbs/acre):	0.10	0.08	20%
Soluble phosphorus concentration in runoff (ppm):	0.3	0.3	0%
Total soluble chemical oxygen demand (lbs/acre):	27.81	26.58	5%
Soluble chemical oxygen demand concentration in runoff (ppm):	100	98	2%
Total sediment yield (tons):	12,198	10,354	17%
Runoff (inches):	1.23	1.2	3%

Vadose Zone Sampling

The only monitoring activity that tied specific land uses to water quality was the Vadose Zone sampling. Results from Vadose Zone sampling were previously described (Section 7.4). Some of the conclusions from this effort are stated below:

- Elevated nitrate levels (20-50 mg/l) were still leaching below the rooting zone two to four years after implementation of Nitrogen Management BMPs. It is likely that it will take several more years before the effects of previous nitrogen mismanagement are leached out of the rooting zone.

- Many sinkholes currently contribute very little nitrate to ground water. Sinkholes surrounded by heavily fertilized or manured land were found to have high nitrate concentrations within the sinkhole.

- Point sources of pollution (pesticide distribution and application facilities) contributed significantly to ground water pesticides. Point sources of pollution should also be targeted in pollution prevention efforts.

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Webers, G.F. 1972. Paleoecology of the Cambrian and Ordovician strata of Minnesota, in Sims P.K. and Morey G.B. eds. Geology of Minnesota: A Centennial volume: Minnesota Geological Survey pp. 474-484.

APPENDIX

Published Reports and General Information Material

Minnesota Pollution Control Agency. 1982. Garvin Brook Watershed Water Quality - General Monitoring for the Rural Clean Water Program. Annual Progress Report, Division of Water Quality. 129 pp.

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Wall, D.B., S.A. McGuire and J.A. Magner. 1989. Water Quality Monitoring and Assessment in the Garvin Brook Rural Clean Water Project Area. Minnesota Pollution Control Agency, Water Quality Division. 287 pp.

Wall, D.B., S.A. McGuire, and J.A. Magner. 1989. Nitrate and Pesticide Contamination of Ground Water in the Garvin Brook area of Southeastern Minnesota: Sources and Trends. Minnesota Pollution Control Agency, Water Quality Division. Presented at the NWWA Conferency "Agricultural Impacts on Ground Water Quality." February 20-21, 1990. Kansas City, Missouri. 17 pp.

Wall, D.B. and C.P. Regan. 1991 Water Quality and Sensitivity of the Prairie du Chien-Jordan Aquifer in Western Winona County. Minnesota Pollution Control Agency, Water Quality Division. 63 pp.

Garvin Brook RCWP quarterly newsletters

Brochure on the Garvin Brook RCWP

Recommended Allowable Limits for Drinking Water Contaminants. MN Dept. of Health

Clean Water-Everybodys Concern. MN Extension Service

Groundwater Pollution Prevention in SE Minnesota's Karst Region. MN Extension Sevice

Tests and Standards for Drinking Water. MN Extension Service

Nitrates in Drinking Water. MN Extension Service

Understanding Nitrogen and Ag Chemicals in the Environment. MN Extension Service

Pesticides and Pesticide Container Disposal. MN Extension Service

Pesticides: Surface Runoff, Leaching and Exposure Concerns. MN Extension Service

Understanding Nitrogen In Soils. MN Extension Service

Rinsing Pesticide Containers. MN Extension Service

Water Quality for Livestock and Poultry. MN Extension Service

Garvin Brook annual report

RCWP-3
(6-24-82)

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Stabilization and Conservation Service

RCWP PROJECT NEEDS, GOALS AND ACCOMPLISHMENTS

1. PROJECT NAME: Garvin Brook RCWP

2. STATE: MN | 3. COUNTY: Winona | 4. CRITICAL ACRES: 20,055

ACTIVITY (5)	TOTAL NEEDS (6)	GOALS (7)	FISCAL YEAR ENDING 19 90 GOALS (8)	FISCAL YEAR ENDING 19 90 ACCOMPL. (9)	CUMULATIVE ACCOMPL. (10)	FISCAL YEAR 19 91 GOALS (11)
A. Treatment Needs 1) Acres needing treatment	10,793	8095-	0	0	7170	0
2) Sources needing treatment a) Dairies (no.)	44	33	4	1	15	0
b) Feedlots (no.)	--	--	--	--	--	--
c) Sinkholes	79	59	22	10	28	14
d) Split-N	10,714	8036	7137	4373	31,643	2267
e) Pesticides	20,255	15,169	7185	4553	38,083	2851
f)						
B. RCWP Contracts Number	125	94	0	0	81	0

12. REMARKS

SIGNATURE (ASCS County Executive Director): W. P. Baron | DATE: 11/20/90 | SIGNATURE (SCS District Conservationist): [illegible] | DATE: 11/20/90

RCWP-4
(6-24-80)

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Stabilization and Conservation Service

RCWP ESTIMATED BMP COSTS

PROJECT: Garvin Brook RCWP 1990

STATE: Minnesota

ITEM	UNIT (A)	NO. OF UNITS (B)	INSTALLATION COST PER UNIT (C)	TOTAL COST (Thousands) (D)	C/S LEVEL (E)	RCWP (F)	FARMER (G)	OTHER (H)	HOUR FACTOR (I)	TOTAL HOURS (J)	SCS 21.00 HOURS (K)	SCS COST (L)	FS 12.00 HOURS (M)	FS COST (N)	SEA 12.00 HOURS (O)	SEA COST (P)	OTHER 12.00 HOURS (Q)	OTHER COST (R)
		TOTAL BMP COSTS				BMP COST SHARES			TECHNICAL ASSISTANCE									
1. RCWP Plan of Work and Annual Review	Hours	1							-	1750.0	1312.0	27552.0	175.0	2100.0	263.0	3156.0	-	-
2. Water Quality Plans a. Development	Farms	81							50.0	4050.0	2926.0	61446.0	314.0	3768.0	810.0	9720.0	-	-
b. Revisions	WQ Plans	202							15.0	3030.0	2032.0	42672.0	124.0	1488.0	874.0	10488.0	-	-
c. Annual Status Review	WQ Plans	635							9.0	5715.0	3921.0	82341.0	524.0	6288.0	1270.0	15240.0	-	-
3. CODE: a. BMP- 1	AC	455.0	233.0	106.0	75%	79511.3	26503.7	-	0.75	341.3	316.3	6642.3	-	-	-	-	25.0	300.0
b. BMP- 2	NO	15	60000.0	900.0	75%	675000.0	123000.0	102,000.0	250	3750.0	2867.1	60209.9	-	-	-	-	882.9	10594.8
c. BMP- 3	AC	559.0	14.75	8.3	75%	6183.9	2061.4	-	0.20	111.8	77.6	1629.6	-	-	-	-	34.2	410.4
d. BMP- 4	FT	14850	2.25	33.4	75%	25059.4	8353.1	-	.03	445.5	428.0	8988.0	-	-	-	-	17.5	210.0
e. BMP- 5	FT	3502.0	1.43	5.0	75%	3755.9	1252.0	-	.01	35.0	30.0	630.0	-	-	-	-	5.0	60.0
f. BMP- 6	NO	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
g. BMP- 7	AC	17.2	1505.87	25.9	75%	19425.7	6475.3	-	13.35	229.6	194.0	4074.0	-	-	-	-	35.6	427.2
h. BMP- 9	AC	4465.0	13.4	59.8	75%	44873.3	14957.7	-	0.60	2679.0	2428.8	51004.8	-	-	-	-	250.2	3002.4
i. BMP- 10	FT	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
j. BMP- 11	NO	26	7529.0	195.8	75%	146815.5	48938.5	-	12.0	312.0	215.6	2587.2	-	-	-	-	96.4	1156.8
k. BMP- 12	NO	5	13676.0	68.4	75%	51285.0	17095.0	-	92.0	460.0	460.0	9660.0	-	-	-	-	-	-
l. BMP- 14	AC	1.9	200.0	0.4	75%	285.0	95.0	-	0.60	1.1	-	-	1.1	13.2	-	-	-	-
m. BMP- 15	AC	6454.0	20.0	129.1	75%	96810.0	45580.0	-	0.20	1290.8	35.6	747.0	-	-	1255.2	15062.4	-	-
n. BMP- 16	AC	6758.0	-	-	-	-	-	-	0.02	135.2	13.0	273.0	-	-	122.2	1466.4	-	-
o. BMP- 17	FT	3000.0	1.67	5.0	75%	3757.5	1252.5	-	0.01	30.0	-	-	30.0	360.0	-	-	-	-
p. BMP- 18	AC	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
q. BMP-																		
r. BMP-																		
s. BMP-																		
t. BMP-																		
Project Total																		

RCWP-5

U.S. DEPARTMENT OF AGRICULTURE

FUND SOURCES AND
ESTIMATED COSTS OF RCWP PROJECTS

Garvin Brook

Minnesota

SOURCE OF FUNDS	FARMER A	ASCS B	SEA C	SCS D	FS E	ESCS F	EPA G	STATE H	OTHER I	TOTALS RCWP J	TOTALS OTHER K	TOTALS PROJECT L
1. BMP a. RCWP		1747000								1747000		
b. Other	582333								180000		762333	
c. Totals	582333	1747000							180000			2509333
2. I & E a. RCWP			83220							83220		
b. Other		20000	6000	3000				7500			36500	
c. Totals		20000	89220	3000				7500				119720
3. Technical Assistance a. RCWP			66468	489450		13560			20876	590354		
b. Other	1000			25000	5000				2500		33500	
c. Totals	1000		66468	514450	5000	13560			23376			623854
4. Monitoring and Eval. a. RCWP 1/												
b. Other	500		3000	37000					14500		55000	
c. Totals	500		3000	37000					14500			55000
Grand Totals	583833	1767000	158688	554450	5000	13560		7500	217876	2420574	887333	3307907

1/ Item 4a will be used only for projects approved for comprehensive monitoring

RCWP-7
(11-25-81)

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Stabilization and Conservation Service

RCWP STATUS REPORT

1. STATE: MN
2. COUNTY NAME: Winona
3. PROJECT NAME: Garvin Brook
4. NO. IN CRITICAL AREA: A. FARMS 168 | B. ACRES 20255
5. BMP FUNDS APPROVED FOR PROJECT: 1747000

MONTH	NO. OF RCWP-1'S FILED	NO. PRIORITIES ESTABLISHED		NO. RCWP-1's TRANSFERRED TO SCS	NO. WQ PLANS PREPARED AND RETURNED TO ASCS	NO. OF RCWP-2'S APPD. BY COC	NO. CANCELLED BY ASCS		NO. RCWP-1's WITHDRAWN BY APPLICANT	CRITICAL ACRES UNDER CONTRACT		FUNDS UNDER CONTRACT	
		HIGH	LOW				RCWP-1'S	RCWP-2'S		ACRES	PERCENT	AMOUNT	PERCENT
6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cumulative to Date	115	57	49	106	82	82	4	0	42	8570	42	1753032	100
OCT	0	0	0	0	0	0	0	0	0	0	0	0	0
NOV	0	0	0	0	0	0	0	0	0	0	0	0	0
DEC	0	0	0	0	0	0	0	0	0	0	0	0	0
JAN	0	0	0	0	0	0	0	0	0	0	0	0	0
FEB	0	0	0	0	0	0	0	0	0	0	0	0	0
MAR	0	0	0	0	0	0	0	0	0	0	0	0	0
APR	0	0	0	0	0	0	0	0	0	0	0	0	0
MAY	0	0	0	0	0	0	0	0	0	0	0	0	0
JUN	0	0	0	0	0	0	0	0	0	0	0	0	0
JUL	0	0	0	0	0	0	0	0	0	0	0	0	0
AUG	0	0	0	0	0	0	0	0	0	0	0	0	0
SEP	0	0	0	0	0	0	0	0	0	0	0	0	0
Total to Date	115	57	49	106	82	82	4	0	42	8570	42	1753032	100

20. REMARKS

21. VERIFIED AND APPROVED BY: (Signature)

TITLE: CED

DATE

NESOTA
ONA
ort ID: EMAH64-R001

U.S. Department of Agriculture
Agriculture Stabilization & Conservation Service
ACP-305 MONTHLY PROGRESS/TRANSMISSION REPORT

Prepared: 10-01-91
As of date: 09-30-91

ogram ode	Fund Code	Total Allocation Amount	Total Amount Approved	Performance Amount Approved	Performance Amount Earned	Balance Available	Amount of Pending Approvals	No. ANA Referrals Total Outstand	No. ANA Referrals Issued this FY	No. of Pending Approvals	No. LTA's Approved this FY
P-ANA	00	200,585	229,477	92,975	63,935	148	4,000	2	112	2	
P-ANA	50	27,676	28,120	4,476	4,032		1,250	4	28	4	
P-ANA		228,261	257,597	97,451	67,967	148	5,250	6	140	6	
P-LTA	00	36,887	18,387			18,500					
P-LTA		36,887	18,387			18,500					
P		265,148	275,984	97,451	67,967	18,648	5,250	6	140	6	
P-ANA		3,139	1,293			1,846	3,588		2	1	
P		3,139	1,293			1,846	3,588		2	1	
CS		10,000				10,000					
WP		451,227	323,230	139,981	86,653	181,325					

ADDENDUM

1.0 PROJECT FINDINGS

- Project started to stagnate when producers in the surface watershed became disenchanted with the goals of the project.

- Because of questionable funding levels, it was difficult to know from year to year what monitoring activities could be performed.

- When producers disagreed with the need for a certain BMP, it often became a stumbling block in the producers willingness to participate at all.

- The Garvin Brook Project faltered somewhat in the early going due to lack of coordination between agencies involved.

- Some landowners in the watershed seemed to be under the impression that this project would be a flood control project.

- Not enough water quality baseline data was available at the start of the project so it was difficult at times to show BMP needs.

2.3.3 I & E Goals and Objectives

This heading was mislabeled as Inventory and Evaluation. It is Information and Education, Goals and Objectives

2.4.2 Summary of Annual Achievements

1983- Well water study and mapping began

1985- Nitrogen Rate Management Plats started
Average Annual Fertilizer Savings
Split Nitrogen Application cost-sharing

1986- Winter Farmer Educational Programs began

1989- Corn Rootworm Insecticide Rate studies began

3.3.3 Number and Proportion of Project Area Producers Implementing each BMP under RCWP from 1981 - 1990

Total Contracts - 81

Best Management Practice	1981 - 1990 Number & Units	Proportion	Participants
BMP1-Permanent Vegetative Cover	25.4 ac	1%	1
BMP2-Animal Waste System	15	19%	15
BMP3-Strip Cropping System	559 ac	5%	4
BMP4-Terrace System	14,850'	1%	1
BMP5-Diversion System	3,502	9%	7
BMP6-Grazing Land Protection	--	--	--
BMP7-Waterway System	17.7 ac	7%	6
BMP9-Conservation Tillage Sys	9,403 ac	93%	75
BMP10-Stream Protection System	--	--	--
BMP11-Perm Cover on Critical Ar	44	30%	24
BMP12-Erosion or Water Control Structures	5	6%	5
BMP14-Tree Planting	1.9 ac	1%	1
BMP15-Fertilizer Management	31,643 ac	100%	81
BMP16-Pesticide Management	38,083 ac	100%	81
BMP17-Woodland Access	--	--	--
BMP18-Water Quality Improvement Through Woodland Improvement	--	--	--

4.2 Cooperative Extension Service Activities

Figure 4.2a and 4.2b

Individual private wells are being monitored to determine Nitrate-Nitrogen levels in parts-per-million.

5.3.6 Off-site benefits of RCWP. Impaired water uses existing before the project which are less impaired by 1990, or are expected to be less impaired in the future.

6.1 Findings and Recommendations

-The monitoring program changed considerably throughout the project duration, shifting focus from surface to ground water monitoring, with increasing emphasis on the vadose zone.

-Long term funding was not secured for monitoring. Without knowledge of long term funding, monitoring strategies were designed to provide useful information regardless of continued funding. A long term monitoring strategy was not developed at the beginning of the project, especially for ground water. The individual studies were not optimal for examining long term trends.

-There was very little understanding of the hydrogeologic system early in the project. As the level of understanding increased, several programmatic changes were made to the program.

-Three laboratories all had consistently different nitrate results from the same water samples.

-Vadose zone monitoring became necessary to more directly link land used with water quality and to understand potential ground water quality improvements within a reasonable time frame.

7.1 Findings and Recommendations

Stream

-Long term stream monitoring sites should be established at both upstream and downstream sites.

-Farm scale monitoring should be conducted in future studies to demonstrate water quality improvements from BMPs.

Vadose Zone and Ground Water

-Soil water samplers should be installed prior to BMP implementation at several depths. Monitoring should be scheduled for 5 to 10 years in the soil water samplers.

-Over 10 years of ground water sampling should be conducted to evaluate ground water response to implemented BMPs. Ground water sampling should be focussed in the upper aquifer(s).

-Point source problems should also be addressed in areas concerned with ground water quality improvement.